STATE RAIL AUTHORITY OF NEW SOUTH WALES

LOCOMOTIVES BRANCH

ELECTRIC LOCOMOTIVES

OPERATING INSTRUCTIONS

F. A. GODFREY
LOCOMOTIVES MANAGER

1981

Reprinted March 2003

HB 4685OP81.DOC

STATE RAIL AUTHORITY OF NEW SOUTH WALES

LOCOMOTIVES BRANCH

ELECTRIC LOCOMOTIVES

OPERATING INSTRUCTIONS

By Authority

F. A. GODFREY,
Locomotives Manager.

1981

SRA.81-38

46 CLASS ELECTRIC LOCOMOTIVES

Photo of side of 4610

46 CLASS LOCOMOTIVES

GENERAL DESCRIPTION

The 46 Class electric locomotives are employed in the haulage of freight and passenger trains, over the various lines within the electrified areas. General particulars are as follows:-

Voltage	1500	D.C.
Wheel arrangement	CO - CO	
Mass	114	Tonnes
Dead hauling mass	120	Tonnes
Axle load	19	Tonnes
Wheel diameter	1133	mm
Bogie wheel base	4270	mm
Total wheel base	12505	mm
Length over buffers	16470	mm
Overall width	2974	mm
Height from rail level to pantograph lowered	4422	mm
Maximum speed	112	km/h
Low tension supply	120	V.D.C.

Photo of Driver's Stand No. 2 end

CAB

The cab has a driving position at each end with comfortable accommodation for driver and observer. The cab ends are specially shaped to give an attractive appearance.

The locomotive houses control equipment, motor generator sets, traction motor blowers, and air compressors. The space between the centre longitudinals of the underframe is enclosed and forms an air duct for the traction motor ventilating air.

The underframe rests on the bogies through centre castings, side bearers, and bearers on the ends of the bogies.

The locomotive is well ventilated by louvres, and provided with circular windows. There is a passage from each driver's cabin to the machinery compartment in the centre.

BOGIES

The bogies are one piece steel castings. On the outer ends of the bogies are mounted buffers and draw gear. The inner ends of the bogies are coupled together by a draw bar having spherical bushes at each end.

The inner ends of the bogies are aligned by a lateral control spring which is provided with an initial compression. Relative movement between the inner ends of the bogies increases the compression of this spring.

Centre castings are provided on the bogie transomes to take the centre castings on the underframe. The bogie centre casting can move laterally on a slide but is restrained in the central position by springs having initial compression.

The centre casting on one bogie is allowed a small amount of longitudinal movement to prevent binding on curves.

At the end of each bogie there is an end bearer mounted on rubber, under compression. These bearers align the bogies with the underframe and take the reaction caused by the tractive effort. The springing on each side of each bogie is fully compensated. Each axle box is provided with a laminated spring and two helical auxiliary springs.

Line Drawing of High Tension Circuits

Axle boxes are of the single bearing self-aligning SKF roller type.

TRACTION MOTORS

There are six traction motors per locomotive, each rated at 475 k.W. at the one hour rating, and 430 k.W. continuously, at 725 amps. The motors have six poles, and are lap wound.

Armature bearings are of the roller type and axle suspension bearings are of the sleeve type. Pinions are of nickel chrome case hardening steel, and the gear wheel rims are of nickel chrome oil hardening steel. The gear wheel rims are mounted on the gear wheel centre through rubber bushes.

The traction motors are located laterally in the bogies by rubber bushed links. This relieves the ends of the suspension bearings of thrust.

The traction motor nose is mounted between rubber pads.

CONTROL EQUIPMENT

The control equipment is arranged for the motors to be connected either six in series, two parallel circuits each of 3 motors in series, or three parallel circuits each of two motors in series. Five weak field positions are provided in each combination. Contactors are of the electro-pneumatic type.

Resistances are of strip metal type. They are provided with blowers which come into operation when the resistances are in circuit for over a prescribed time.

Provision is made for regenerative braking in series and series-parallel.

The control voltage is 120 D.C.

There are two motor generator sets each driven by 1500 volt motors. One set includes a 120 volts D.C. generator which provides power for lighting, control and battery charging. The other set includes a variable voltage generator which is used for separately exciting the traction motor fields during regeneration and for the supply of current to the resistance fan motors.

Line Drawing of Traction Motor Combinations

Each motor generator set also drives a fan which discharges into the air duct between centre longitudinals of the underframe and passes thence to the traction motors. Each motor is blown with 71m^3 per minute.

The battery consists of 54 cells of the lead acid type with a capacity of 50 amp hours.

The two pantographs are of the double pan type. They are raised by air pressure controlled by electro-pneumatic valves operated from the driver's position. A hand pump is provided for use in the absence of air pressure.

BRAKE EQUIPMENT

There are two air compressors, each driven by a separate electric motor.

Each compressor has a displacement of 2m^3 per minute.

Both compressors are controlled in their output by a square "D" type compressor governor. Brake equipment is of the Westinghouse A7-EL type.

PERFORMANCE

The locomotives are designed to haul 1120 tonnes at 60 km/h on rising grade of 1.1% and 410 tonnes at 60 km/h on rising grade of 3%. Where grades and curves permit they can haul passenger trains at 112 km/h.

MOTOR COMBINATIONS

Each locomotive is equipped with six M.V.272 traction motors which are axle mounted. Motors Nos. 1, 2 and 3 are on one bogie and motors Nos. 4, 5 and 6 on the other bogie.

The motors can be connected in any of three speed combinations by electro-pneumatic unit switches:-

1. Series - six motors in series.

2. Series-Parallel - two parallel circuits each of three motors in series.

3. Parallel - three parallel circuits each of two motors in series.

In each combination resistance is first included in circuit with the motors. It is cut out by moving the accelerating handle of the master controller from the off to No.20 position.

After all resistance has been cut out in each combination there are five stages of weak field.

MASTER CONTROLLER

There is a master controller in each driving cabin. It has the following three handles.

Reversing Handle

This handle has three forward positions which are:-

Forward series,
Forward series-parallel,
Forward parallel.

It has two reverse positions which are:-

Reverse series,
Reverse series-parallel.

The reverse handle can only be removed when it is in the off position. It can not be moved to or from the off position unless the accelerating handle is in the off position.

Accelerating Handle

The accelerating handle has the following positions:-

0 Off position.

1-20 Accelerating notches, commencing on notch 1 with all resistances in circuit with the motors, and ending on notch 20 with no resistance in circuit.

21-25 Weak field notches. These notches give higher running speeds than notch 20 which is a full field notch.

Regenerating Handle

This handle is used for regulating the strength of the traction motor fields during regeneration and therefore the speed. It has the following positions:-

Mot This position corresponds to the off position of the handle. The handle is always left in this position except when regenerative braking is taking place.

1-15 In these positions the traction motors are separately excited for regeneration and the field strength is increased from position 1 to position 15. 1 is the highest speed running position and 15 the lowest speed position.

The regenerating handle cannot be moved from or to the motoring position unless the accelerating handle is in the off position.

Although regeneration is set up by moving the regeneration handle to any of positions 1 to 15 it does not actually commence until the accelerating handle has been moved to the first position. The accelerating handle should then be steadily moved to position 20.

MAIN ISOLATING SWITCH

The switch is unlocked by inserting the reverser handle into the slot of the High Tension Door Interlock, and pushing the reverser handle up, removing it from the slot and re-inserting it again to push up for the second time to free the double action isolating switch. The door interlock lever can now be pushed up to the horizontal position, which will release the bolts on High Tension doors.

The H. T. interlock lever can not be moved to the horizontal position, until the pantographs have been lowered and the double action isolating switch open.

CONTROL SWITCH

In order to obtain control current for the pantograph raise circuit, and master controller it is necessary that the control switch be closed.

It is important that when locomotives are coupled together, with the jumpers inserted, only one control switch should be closed on all locomotives.

OVERLOAD RELAYS

In case of a fault on the 1500 volt equipment, the locomotive is provided with overload and differential overload relays which will trip and open the line switches to cut off power.

The overload relays trip if excessive current 1250 amps passes through their coils. The differential overload relay trips if the amount of current flowing into the power circuit is different from the amount flowing out. This indicates an earth fault in the equipment. It is necessary to set the differential overload relay if the control switch has been turned off.

Overload relays are reset by pressing the "reset" buttons on the driver's panel. The top button resets the overload and differential overload relays, the bottom button resets the overvoltage relay.

They should not be reset more than twice in succession. Repeated resetting will damage the equipment and may result in a fire.

When the accelerating handle is in the open position, the tripping of the overload relays is indicated by the presence of the red line switch indicator light.

OVERVOLTAGE RELAY

This relay is required during regeneration and opens the line switches if the voltage which is being generated exceeds 2,050 volts. It is reset by pressing the reset button on the driver's switch panel.

Neither the overload relays nor the overvoltage relays can be reset unless the accelerating handle of the master controller is in the off position.

NO CURRENT RELAY

The no current relay will operate upon the loss of the overhead power supply and open the line switches.

To reset the no current relay return the accelerating handle to the off position.

AUXILIARY DIFFERENTIAL OVERLOAD RELAY

In the event of a flash-over to earth on either of the motor generators, this relay will operate and open the motor generator high tension contactors, thus causing a failure of the supply motor generator which will be indicated by the presence of the yellow light. To reset the auxiliary differential overload relay, switch off the motor generator tumbler switch on the driver's desk, then after a slight pause, switch on again. This action will automatically reset the auxiliary differential overload relay, if the cause of tripping is minor.

The resetting of the auxiliary differential overload relay must be restricted to twice only, as repeated tripping may be due to the continual flashing over which could cause serious damage to the generator.

In case of failure of the supply motor generator, it is important that the driver operates the supply motor generator tumbler switch to ensure that the auxiliary differential overload relay has not tripped.

MOTOR GENERATOR CONTROL SWITCHES

While the locomotive is in service it is necessary for both the motor generators to be running to provide ventilating air for the traction motors. Also the supply motor generator set must be running to provide 120 volt control current and keep the battery charged.

The motor generators are to be running at least five minutes before locomotive movement commences and are to be kept running whilst the locomotive is working and making demands on battery current. The motor generators are to be kept running for a period of not less than five minutes after the cessation of any locomotive movements.

Each motor generator set is provided with a no current relay which makes contact if the machine is not running, and lights a yellow lamp in each driver's cabin, as a warning to the driver.

For the supply motor generator to be running, the miniature circuit breaker in the low tension cabinet No. 2 end and the motor generator two-way tumbler switch on one of the driver's desk panels must be closed.

Photograph of P&C Gauge and 3-Way Cock

The supply M.G. circuit breaker is located in the low tension cabinet No. 2 end. The M.G. switch is labelled "motor generators", and is located on the Driver's stand.

For the exciter motor generator to be running it is necessary that the miniature circuit breaker in the low tension cabinet No. 2 end should be closed and the supply motor generator to be running.

Both motor generator sets are protected by an auxiliary differential overload relay which will operate if a defect occurs in either set. The auxiliary differential overload relay is reset by switching off the motor generator switch on the driver's panel. On switching on, the generator sets should operate unless a sustained fault is present.

AIR COMPRESSOR CONTROL

For the air compressors to be running, it is essential that the two compressor switches in the No.2 low tension electrical cabinet are turned on. There is a separate switch for each compressor, and either compressor may be operated separately when required.

Under normal operating conditions, both compressor are to be switched on at all times.

A "D" type electro-pneumatic governor is provided in the compressor control circuit. When main reservoir air pressure rises to the pressure at which the governor is set, normally 800 kPa, the governor stops the operation of the compressors. When the pressure has fallen to 700 kPa, the operation starts again.

PANTOGRAPH CONTROL

The pantographs are raised by air pressure from the pantograph and control reservoir. When the locomotive has been shut down for some time, the pantographs are raised by air from the pantograph storage reservoir, or by a hand pump.

In the air supply pipe line to the pantograph cylinders there is an isolating cock which is connected to the inter-locking mechanism for the doors of the high tension compartments. This prevents the pantographs being raised until the doors are closed and locked. The pantograph raising magnet valve must be energised to open the air valve and allow air to flow to the pantograph cylinder

Line Drawing of Resistance Fan Motor Circuits

The air supply to the pantograph also passes through a three-way cock. The three positions of this cock are as follows:-

1. In this position the handle is horizontal and the pantographs are connected via their electro-pneumatic magnet valves to the pantograph and control reservoir air supply. This is the normal position of the cock whilst the locomotive is in service.

2. In this position the handle points upwards and the pantographs are connected via their electro-pneumatic magnet valves to the storage reservoir. In this position one of the pantographs can be raised from the storage reservoir by opening the storage reservoir wheel valve. Should the storage reservoir have no air pressure, the pantograph may be raised by using the hand air pump. The storage reservoir wheel valve is to be turned off before using the hand pump.

3. In this position the handle is vertical pointing downwards. The storage reservoir is connected to the pantograph and control reservoir air supply, so that, it can be charged by opening its wheel valve. After charging, the wheel valve should be tightly closed to prevent loss of air. In this position the pantographs are lowered and isolated.

There are two pantograph electro-pneumatic magnet valves one for the control of each pantograph. Each magnet valve is operated by two push buttons, "up" and "down" in each driving cabin. This enables all front or all rear pantographs to be operated together when locomotives are coupled for multiple unit operation.

Each pantograph magnet valve has an isolating cock fitted, which will isolate the air supply to the pantograph roof cylinder.

During normal working both isolating cocks should be open.

The pantograph push buttons are located to the left of the switch panel.

CONTROL OF RESISTANCE FAN MOTORS

The main resistances are ventilated by motor driven fans which start up after power has been on the main resistors for one minute. They keep running for three minutes after current has ceased to flow in the resistances.

During some master controller operations the resistance fans will not operate, it is only when acceleration is unduly prolonged and during regeneration that the fans operate.

Operation of the resistance fans is shown in each driver's cabin by a yellow indicator light which lights up when power is applied to the resistances and will remain alight for approximately one minute whilst resistance is in circuit. As soon as all fans start running or when the acceleration handle is moved to No.20 position the light will go out.

The same lamp will shine as an indication that the motor generators are not running.

Should this light remain on for more than one minute there is a possibility of the resistances becoming over-heated and providing the motor generators are operating correctly, the resistance fan motor miniature circuit breakers should be checked to ensure one or more have not tripped.

WHEEL SLIP WHITE INDICATOR LIGHT AND BLEEPER

The wheel slip relays fitted to 46 class locomotives are for the purpose of warning the driver of the slip in motoring or slide in regenerative braking of any of the locomotive wheels.

When wheel adhesion to the rail is correct, a similar volume of current is fed to each traction motor (which is pinioned to the related locomotive axle); when any wheel slips the armature of the traction motor has to rotate faster and there is a differential of current feed, there-fore, between the gripping and the slipping wheels.

This condition brings the wheel slip relay to life and feeds control current to operate the wheel slip bleeper and white indicator light. The control current to operate the bleeper and white indicator light is supplied through the auxiliary control circuit breaker No. 2 end.

An additional relay has been fitted to operate the wheel slip bleeper and light whenever the master controller accelerating handle is positioned at notch 1.

This arrangement is intended as a warning that current is being fed through the resistances and with such insistence that a driver cannot erroneously return the throttle to notch 1, when intending to shut off.

Should the wheel slip bleeper and light fail to operate with the master controller accelerating handle at notch 1, it may be due to auxiliary control circuit breaker in No. 2 end being tripped. This would result in a failure of the sand gear and an immediate examination should be made to ensure this circuit breaker is turned on.

HEATERS

Each driver's cabin is provided with one high tension (1500V) heater, two low tension (120V) window and foot heaters and a food heater.

These are controlled by separate switches which are located in the driving cabin. Their circuits are protected by circuit breakers located in No. 2 low tension compartment.

The current for the low tension heating circuits is supplied from the supply motor generator and high tension heater, from overhead supply.

ISOLATING COCKS

The isolating cocks provided in each locomotive are listed below together with the correct running position of each cock.

Brake valve isolating cock at driving end	open
Brake valve isolating cock at non driving end	closed
One compressor governor isolating cock	open
One main reservoir isolating cock	open
Two pantograph isolating cocks	open
Two pantograph and control reservoir isolating cocks inlet and outlet	open
Three-way pantograph cock	open handle horizontal (towards corridor)
One switchgroup isolating cock	open & sealed
One time-delay reservoir isolating cock	open & sealed

(Blank Page)

Photo of Low Tension Cubicle

One sander isolating cock	open
One distributing valve isolating cock	open
One Vigilance Control main reservoir isolating cock	open & sealed
One Vigilance Control brake pipe isolating cock	open & sealed
One dead engine cock	closed
Two brake cylinder isolating cocks	open
All drain cocks	closed
Hose coupling cocks not connected to adjacent locomotive	closed
One isolating cock underneath the driver's seat isolates the air supply to both air ride seats in the cab	open
One locomotive whistle isolating wheel valve located below roof level, one in each cab	open
One main isolating wheel valve in No.2 cab	open

SWITCHES AND CIRCUIT BREAKERS

LOW TENSION CUBICLE (No. 2 Electrical Cabinet)

All circuit breakers and switches are located in the No.2 low tension electrical cabinet, together with control equipment as follows:-

1. Voltage regulator and control.

2. Battery switch.

3. Battery charging ammeter.

4. Two (2) compressor switches.

5. Two rows of circuit breakers which protect the following circuits:-

   (a) 10 amps - No.1 end lights
   (b) 10 amps - No.2 end lights
   (c) 10 amps - corridor lights
   (d) 10 amp - compressor control
   (e) 10 amp - supply motor generator
   (f) 30 amp - main control
   (g) Spare
   (h) 20 amp control pos. 1
   (i) 20 amp control pos. 2

(j) 10 amp auxiliary control
(k) 10 amp vigilance control
(1) 10 amp voltage regulator
(m) 10 amp exciter control
(n) 10 amp food heater
(o) 10 amp cab heater
(p) 20 amp window & foot heater
(q) spare

The function of the circuit breakers is self-explanatory with the exception of the following:-

(f) Main Control - protects all low tension circuits to the master controller, indicator warning lights, vigilance control and Hasler speed recorder.

(d) Compressors - both compressor circuits.

(e) Supply motor generator - protects the supply motor generator control circuit.

(h) Control positive No.1 circuit - protects all master controller circuits except weak field also the fan indicator light.

(i) Control positive No.2 circuit - protects all master controller weak field circuits.

(j) Auxiliary control - protects pantographs, sander circuit and wheel slip bleeper.

(m) Exciter control - protects the exciter motor generator control circuit.

Corridor, (Adjacent to each cab door)

Corridor light switch.

Machinery Compartment

8 - Resistance Fan M.C.B.'s (4 in each of two cupboards on H.T. compartment walls).

To operate locomotive lights the battery isolating switch must be closed, together with the lighting M.C.B.'s. Individual groups of lights are then controlled by their respective switches as required.

PREPARATION AND STABLING

1. In the event of any equipment being found "cut out" unless labelled "Not to be used", or in the absence of a relevant entry in the Log Book, such equipment must be "Cut In".

2. If any authorised employee be at work on an electric locomotive at the time when the driver arrives to commence testing operations, and if such work is likely to affect the electrical or air equipment, the driver must not proceed with the testing operations on the locomotive concerned, or cause the locomotive to be moved, until the work has been completed and all danger discs removed from the departure end of the locomotives.

3. When an electric locomotive is stabled at a depot, the procedure outlined for stabling must be carried out by the stabling driver, unless instructed not to do so by the Locomotives Supervisor.

PREPARATION

Obtain Driver's Daily Report Sheet, Reverser Key and Control Key. On arrival at locomotive observe that both pantograph isolating switches are closed. Peruse Log Book and commence preparation at No .2 end.

No.2 Cab

The following items are to be checked:-

1. Hand brake is applied.

2. Low Tension cabinet.

   (a) All circuit breakers are switched 'on'.
   (b) Close battery switch.

   NOTE: The battery switch is to be open before the low tension fuses are renewed.

3. Driver's brake valve isolating cock is closed.

Photos of Spare Fuses and Fuse Tester.

4. All switches on driver's control panel, not required, are switched off.

Whilst passing through the locomotive to the No.1 end, check the following spare equipment:-

(a) 3 control jumpers. Black, Red and Grey.

(b) Equipment boxes are closed and sealed.

(c) Hook stick is in position.

(d) 3 fire extinguishers are sealed.

Machine (centre) compartment

The following items are to be checked:-

1. The resistance fan motor circuit breakers are switched 'on', four in each cabinet.

2. Test the 160 amp. 40 amp, 18 amp, spare fuses which are located on one end of the regenerative electrical cabinet. A fuse tester with light and switch are provided on the opposite end of the box.

3. Compressors oil level is sufficient.

4. The main reservoir, sanding relay, distributing valve, pantograph and compressor governor isolating cocks are open.

5. The fan time delay reservoir, switch group and vigilance control isolating cocks are open and sealed.

6. The dead locomotive device is closed.

7. Unlock high tension door interlock with reverser key (two movements) and move operating lever up.

No. 1 Cab

The following items are to be checked:-

1. Low tension cabinet for supply of spare globes.

2. Driver's brake valve isolating cock is closed.

3. All switches on driver's control panel, not required, are switched off.

4. Insert control key and switch 'on'.

5. Press pantograph raise button.

No.1 High Tension Compartment

1. Check that the required high tension fuses are in circuit.

2. Operate wheel slip relays, check bleeper and light functions.

No.2 High Tension Compartment

1. Operate wheel slip relays, check bleeper and light functions.

   Ensure high tension doors are closed correctly, proceed to machine compartment, move operating handle of high tension door interlock down and lock with reverser key (two movements).

To raise pantograph

1. Ensure one pantograph raising magnet valve is energised. Move three-way cock to 'horizontal' position and open outlet cock from pantograph and control air reservoir.

2. Should this method fail, place three-way cock in 'upward' position and open wheel valve on storage reservoir.

3. If pantograph fails to rise, close wheel valve on storage reservoir and operate hand pump until pantograph makes good contact with the overhead wire by observing the line volt meter.

4. Proceed to the No.2 cab, switch on the compressors, then return to machine compartment and open inlet cock to pantograph and control air reservoir.

NOTE: It is necessary to keep pumping until main reservoir pressure is 500 kPa, and three-way cock is moved to the 'horizontal' position.

Departure end

1. Switch 'on' supply motor generator. The exciter motor generator will start up automatically when the supply motor generator is up to speed.

2. Open driver's brake valve isolating cock and test independent and automatic brake valves in the following manner:-

NOTE: During the following test the "cutting in" and "cutting out" points of the air compressor governor should be checked. The vigilance control button is to be operated and the volume timing reservoir pressure maintained in the operating zone, whilst the brake test is being carried out. Any irregularities detected should be reported, this also applies to incorrect pressures or adjustments that are noticed on other tests.

Test 1 - Air Pressure

With main reservoir fully charged, place both driver's brake valve handles in "running" position, check air gauges to ensure that correct air pressures are being carried. Main reservoir pressure should be governed within the limits of 700 to 800 kPa. The brake pipe and equalising reservoir pressure must be adjusted to 500 kPa.

Test 2 - Minimum Reduction Feature

Move the automatic brake valve handle to "lap" position and check that the "minimum reduction" feature is operating by observing the brake cylinder pressure rises to approximately 105 kPa and the brake pipe and equalising reservoir pressure is reduced by approximately 50 kPa.

Test 3 - Independent Release of Automatic Brake

Move the independent brake valve handle to "release" position, and note brake cylinder pressure reduces to zero, then return brake valve to running position.

Test 4 - Automatic Brake Valve - Service Operation

Reduce the brake pipe pressure by a further 140 kPa by means of the automatic brake valve and note the rise in pressure as shown on brake cylinder air gauge.

Test 5 - Regenerative Interlock

Before making the regenerative interlock test place the reverser key in forward series, press overload and overvoltage reset buttons, then place the accelerating handle in the first notch noting that a current reading is

recorded on the ammeter. Return the accelerating handle to the off position. With the supply motor generator and the exciter motor generator running, reverser key in forward series, turn the control key off and then turn it back on, place the regenerative handle in first position and with the accelerating handle also in the first notch, note that the air brake application releases on the locomotive.

Test 6 - Regenerative Interlock

Reduce the brake pipe pressure to zero, and check that the pneumatic control switch operates to cut out regenerative brake and that the air brake re-applies on the locomotive. Return the accelerating handle to the 'off' position.

Test 7 - Flowmeter Test

Return the automatic brake valve handle to "running" position and note that one hand of the Flow Indicator Gauge momentarily drops towards zero and then returns to the normal fully charged position, overlapping other hand.

Test 8 - Independent Application with Regeneration

Place the accelerating handle in the first notch.

Move the independent brake valve handle to "slow" application position and check that a brake application is obtained and that the setting of the reducing valve (325 kPa) is correct and leave brake valve handle in this position. Move the accelerating handle to the "off" position, the regenerative handle to "MOT" and reverser key to "off" position.

Test 9 - Distributing Valve Safety Valve

Reduce brake pipe pressure fully with the automatic brake valve handle in emergency position and check that the distributing valve safety valve lifts when 400 kPa brake cylinder pressure has been obtained. Release brakes by returning both brake valves to "running position".

3. Move reverser key to forward series position. Move accelerating handle to the first notch position and then back to 'off'. Operate sanding foot button. Return reverser key to 'off' position and remove key. Switch off supply motor generator tumbler switch.

Apply the independent brake fully and then remove the brake valve handle. The observer is to proceed to the opposite end with the independent brake valve handle, apply the hand brake, insert the brake valve handle and then release and fully re-apply the brakes. The driver upon observing the release and re-application of the brakes on the brake cylinder gauge will reduce the brake pipe pressure 140 kPa by placing the automatic brake valve in the service position. Close the driver's brake valve isolating cock and remove the brake valve handle.

4. Examine front of locomotive, checking all air cocks are closed and air hoses properly secured to dummy couplers. See automatic coupler is in good order and jumper receptacle lids properly closed.

5. Pass along 'off' side of locomotive. Examine brake shoes and riggings, springs etc. Check that brake cylinder isolating cocks are open, sand boxes full and working correctly and brake piston travel between 75 to 150 mm. Drain water from main reservoirs. Vigilance control main reservoir isolating cock open and sealed.

6. Enter rear cabin and carry out instructions as previously outlined under departure end. Note that air pressures indicated on the air gauges do not materially differ from those indicated at the other driving compartment. Set required tail lights and release hand brake if applied.

7. Examine rear and 'on' side of locomotive as outlined in instruction 4 and 5.

8. Enter departure end cab. Open driver's brake valve isolating cock and release hand brake. Raise and lower pantographs to ensure correct operation. Lower the leading pantograph if it is not required. Insert reverser key in master controller in readiness to depart.

9. During the preparation of the locomotive, check hand lamp, red flags, detonators and tail disc, test head, pilot, marker, gauge and interior lights and set required head and marker lights.

OPERATION PROCEDURE

ACCELERATION IN SERIES

To start a train or light locomotive the following procedure is necessary:-

1. The control switch must be in the 'on' position.

2. Place the reverser key on the master controller and move it to series forward or reverse as required.

3. Press the overload reset button.

4. Release the air brakes.

The accelerating handle can then be moved to the first position and after a pause to the second position and so on.

When the locomotive is light it should move in the first notch position. If attached to a train it may be necessary to move the accelerating handle to the 4th or 5th position to obtain train movement.

When the train has started the accelerating handle should be moved step by step to position 20. The peak current measured on the ammeter should not exceed 900 amps during notching. Peak currents in excess of 800 amperes will probably require the use of sand to prevent wheel slip. Another notch should not normally be taken until the current drops below 800 amperes.

When the accelerating handle has been placed in position No. 20, it can be left in that position if no higher speed is required. Generally this speed will be insufficient and it will be necessary to pass to the next combination, in accordance with the following description.

TRANSITION FROM SERIES TO SERIES-PARALLEL

To change into the series-parallel combination the reverse handle is moved from "forward series" to "forward series-parallel".

The accelerating handle is then returned to notch 1 position with the button on the end of the handle depressed. The depressing of the button on the end of the handle prevents the accelerating handle being moved to the off position during transition, this prevents the line switches from opening and cutting off power.

No change takes place until the accelerating handle is returned to notch 1 when transition to "series-parallel" takes place with all resistances in circuit. The handle should then be advanced step by step to position 20 as before.

TRANSITION FROM SERIES-PARALLEL TO PARALLEL

If a higher speed is required, transition to the parallel combination should be made. The reverse handle should be moved to "forward parallel" position and the accelerating handle returned to No.1 position when transition to parallel will take place with all resistances in circuit. The accelerating handle should then be moved step by step up to notch 20 as before.

WEAK FIELD NOTCHES

There are five (5) positions of the accelerating handle after notch 20. In these positions the fields of the traction motors are weakened which increases the locomotive speed.

These notches should be used if a higher speed than can be obtained in full field is required, and if the next higher motor combination will give too high a speed.

When operating in weak field combinations, the accelerating handle is to be reduced one notch, each time the current exceeds 750 amperes.

This applies in all combinations.

When maximum traction effort is required, particularly when operating in series and assisting a diesel hauled train, weak field notches should be used to hold motor current above 650 amperes.

RUNNING NOTCHES

Positions 20 to 25 of the accelerating handle are running notches, and the handle may be left continuously in any of these positions. It should not be left continuously in positions 1 to 19, as in these positions resistances are in circuit with the traction motors and they are not designed for continuous operation. An exception to this instruction is given under series regeneration.

REVERSING

The reverser key should never be moved to reverse position while the locomotive is moving forward, nor to forward while the locomotive is moving in reverse. The locomotive should be stopped before a change in the direction of the reverser key is made.

WHEELS SLIPPING

The wheel slip relays operate a lamp and bleeper in each driver's cabin if a wheel slip occurs. The lamp and bleeper also operate during transition changes and where ever the accelerating handle is in the first notch position.

Wheel slips should be quickly corrected by the use of sand and by a reduction in power, by moving the accelerating handle towards the off position until the slip is arrested.

In weak field combinations a slipping speed high enough to burst an armature can be attained if these notches are used above the current prescribed.

REDUCTION OF SPEED

When it is necessary to reduce speed, the accelerating handle should be returned to the off position, the reverse key moved to a lower speed combination and the accelerating handle advanced rapidly to notch 20.

SECTION INSULATIONS IN OVERHEAD WIRE

Section insulators in the overhead wire separate sections of the wire and there may be a difference of voltage on each side.

To reduce sparking at section insulators whenever practicable the locomotive should be coasted under them. Drivers should endeavour to switch off power while the pantographs are passing under section insulators.

REGENERATIVE BRAKING

During regeneration the power generated by the motors is fed back to the overhead wire for use by other trains.

Regenerative brake is available in the series combination at speeds of approximately 25 km/h.

Maximum retardation is available at 25 km/h, but above this speed the maximum amount of braking effort obtained falls off in inverse ratio to the speed. For instance at 50 km/h, the maximum braking effort obtainable is only half that obtainable at 25 km/h.

Regenerative braking is also available in the series-parallel combination at speeds of 50 km/h and upwards. In this case full braking can be obtained at 50 km/h and the maximum braking falls off in inverse ratio to the speed.

It should be noted that full braking effort can be obtained at only two speeds, namely 25 km/h in series and 50 km/h in series-parallel.

Operation at other speeds means a reduction in the amount of braking obtainable.

The maximum loads which can be braked at a steady speed on different grades without overheating the traction motors, or danger of wheel sliding are as follows:-

Grade	Load which can be braked in series at 25 km/h or series-parallel at 50 km/h
3%	590 tonnes
2.5%	775 "
1.7%	1275 "
1.25%	1887 "
1.1%	2193 "

WHEN REGENERATIVE BRAKING SHOULD BE USED

The regenerative brake is designed to maintain an approximately constant speed when descending grades and it should be used for this purpose. If rapid deceleration or a stop is required the automatic air brake should be used.

As the regenerative brake is applied only on the locomotive care must be taken to avoid sudden application or release which would impart a shock on the train.

OPERATION OF MASTER CONTROLLER IN REGENERATION

If the speed is between 25 km/h and 50 km/h, place the reverser handle in "forward series".

If the speed is above 30 km/h place the reverser handle in "forward series-parallel".

Place the regeneration handle on a notch corresponding to the speed.

The following table shows the position of the reverser handle and regeneration handle for various speeds:-

Approx. Speed km/h	100, 70, 50, 25	50, 30, 20, 15,
Combination	Series-Parallel	Series
Regen. Notch	1, 5, 10, 15	1, 5, 10, 15

The proper position of the handle is indicated by the reading of the motor voltmeter which should approximately balance with the line voltmeter.

When the regeneration handle has been placed in the appropriate position with the line and motor volts balanced, the accelerating handle should be moved steadily round to No. 20 position.

The regeneration handle should then be moved to suit the speed and braking effort required. Movement of this handle should always be effected slowly.

Movement towards notch 15 increases braking effort and movement in the opposite direction decreases it.

TO SWITCH OFF

When it is desired to switch off regeneration the regeneration handle should be moved slowly until the armature current is zero. The accelerating handle should then be returned to the off position. The regeneration handle should then be returned to the motoring position.

If while regeneration is in operation it is necessary to make a rapid decrease in speed, the automatic air brake should be applied on the train. It is important that as soon as the armature current reads zero the accelerating handle should be returned to the off position, otherwise the locomotive may take a motoring mode.

CHANGE OF COMBINATION

To change from series to series-parallel or vice versa in regeneration it is necessary to switch off, adjust the speed of the train with the air brake and commence regeneration again in the new combination.

CONNECTION OF REGENERATION WITH AIR BRAKE

When the accelerating handle is moved from the off position to commence regeneration, an interlock magnet valve on the distributing valve is energised. This enables an automatic air brake application to be made on the train without taking effect on the locomotive.

If, however, an emergency application of the automatic brake is made, the heavy reduction of brake pipe pressure operates the pneumatic control switch which cuts off the regeneration interlock magnet valve, so that, an emergency brake application is effective on the locomotive as well as on the train.

WHEEL SLIDING DURING REGENERATION

The motor armature current should be kept at less than 700 amperes to prevent wheel sliding during regeneration. If wheel slide occurs, the speed of the train will increase rapidly, so a close watch on the speed must be kept.

If wheel slide occurs an immediate application of the automatic air brake should be made to check the speed. This will reduce the braking effort being exerted by the locomotive and stop the wheel slide. At the same time the regeneration handle should be moved to reduce the amount of braking.

OVERVOLTAGE PROTECTION

If the voltage generated by the traction motors exceeds 2050 volts the overvoltage relay will trip and cut off regeneration. Care should be exercised in setting up regeneration not to allow the motor volts to greatly exceed the line volts before connection is made to the line by movement of the accelerating handle to notch 20.

If the overvoltage relay trips during regeneration an automatic air brake application should be made. The accelerating handle should be returned to the "off" position and the regenerating handle to the motoring position. The overvolt reset button should then be pressed after which regeneration may be commenced again.

The line voltage should not be allowed to exceed 2000 volts. It can be reduced by a reduction in the amount of current regenerated, and if necessary using the automatic air brake to supplement the regenerative braking effort.

START IN SERIES REGENERATION

A train may be started in series regeneration from rest if on a falling grade.

The regeneration handle should be placed in notch 2, and the accelerating handle advanced notch by notch to position 20 , and the regeneration handle adjusted as required.

The locomotive will take a motoring current to start after which on a falling grade a braking current will be generated.

A start in series-parallel regeneration from rest must not be made.

RESISTANCE IN SERIES REGENERATION

In series regeneration the accelerating handle may be moved back as far as notch 12 to insert resistance in the motor circuit, this will allow of a slight increase in speed in this combination. This working does not apply to series-parallel regeneration.

LOSS OF OVERHEAD POWER

Loss of overhead power to a locomotive can arise from two possible causes, namely:-

(i) A fault within the electrical equipment of the electric rolling stock.

(ii) Loss of supply to the overhead wiring caused by an overhead wiring fault or by loss of supply to a sub-station.

ELECTRIC LOCOMOTIVES - SINGLE UNITS

(i) As soon as possible after the initial loss of power, return the master controller to the "off" position and if using regenerative brake, the regenerative handle to the "MOT" position. Avoid stopping with any portion of the train on a bridge, viaduct, catch-points, crossing or in a tunnel, under an air gap, or any position likely to obstruct trains on another line.

If supply is not available two minutes after the initial loss of power, the driver should switch off motor generators and compressors, lower pantographs, observe that they are lowered and charge storage reservoir.

(iii) Four minutes after the initial loss of power the driver should raise one pantograph and arrange to have it carefully observed when it makes contact with the overhead wire.

(iv) If a flash occurs and power goes off immediately, as indicated by the line voltmeter in the driver's cabin. It is probable that there is a fault on the locomotive. If such is the case, the pantograph should be lowered and arrangements made for a relief locomotive to be obtained.

(v) If power is restored and remains restored, proceed.

(vi) If there is no flash at the pantograph and power is not restored the pantograph should be lowered.

(vii) The pantograph should be raised after a further period of two minutes for a similar test. If there is no indication of return of power it should be lowered again. The observer should then be sent to communicate with the nearest signal-box.

(viii) The driver should act on instructions received from the Signalman and, unless he has definite knowledge that his locomotive is defective, he should raise a pantograph every five minutes to test for the return of power and lower it if power has not been restored.

(ix) He should make arrangements for the securing and protection of the train as required in accordance with the regulations.

ELECTRIC LOCOMOTIVES - MULTIPLE UNIT

In the case of electric locomotives in multiple unit consists, the driver should carry out the Instructions detailed above for single unit electric locomotives except that operation (iii) should be applied to one pantograph of the leading locomotive, and operation (vii) to one pantograph of the trailing locomotive.

PROTECTION OF TRAIN

The train crew must make arrangements for protection of the train where required in accordance with the provisions of Rule No. 243.

LOSS OF OVERHEAD POWER ON HEAVY GRADIENTS

If overhead power is lost when a train is ascending or descending a heavy gradient an immediate application of the automatic air brake is to be made to stop the train which is then to be secured by the application of sufficient hand brakes to hold it stationary on the grade and the automatic brake released. This instruction must be observed at all times, as it is essential that the train be brought to a stand before main reservoir pressure has been depleted. When power is restored, full main reservoir pressure must be obtained before the hand brakes are released.

PANTOGRAPHS

Most wear on the overhead wire is caused by passage of current to the pantograph strips rather than by friction between wire and strips. It is therefore desirable at all times when hauling a train to operate with both pantographs raised. The current density at the pantograph strips is thereby kept as low as possible and the rate of wear on the overhead wire kept as low as possible.

The number of pantographs to be raised is summarised below:

Location Between places stated	Number of pantographs to be raised on each locomotive			
	Metropol-itan Area generally	Rhodes and Gosford Liverpool and Glenlee	Nepean River Bridge and Katoomba	Katoomba and Lithgow
Light Engines				
one, two or three locomotives (d)	1	1	1	1
Hauling Trains				
single locomotives any speed	2	2	2	2
Two units coupled				
below 90 km/h	1	2	2	2
above 90 km/h	1	1	(a)	(a)
Three units coupled				
any speed (c)	1	1	2	1(b)

NOTES: The rear pantograph should normally be raised where only one is permitted.

(a) Speed not to exceed 90 km/h on this section.

(b) Two pantographs should be raised on each locomotive between Lithgow and Newnes Junction only in the up direction.

(c) Locomotives must not be operated in parallel.

To comply with these instructions, it will be necessary for drivers of coupled electric locomotives to raise and lower the pantographs, if necessary, when passing the following points:-

West: Penrith - Katoomba - Newnes Junction (up only)

North: Rhodes

South: Liverpool

North Shore: Hornsby

Pantographs may be raised or lowered with the locomotive(s) in motion, providing the master controller is first moved to the off position. It is important to ensure at all times that pantographs are in the fully raised or lowered position, to avoid damage to overhead equipment.

MULTIPLE UNITS

When operating with multiple units, the normal practice is for all locomotives to have the jumper couplings inserted between them, thus providing for control of all locomotives from the leading driver's cabin.

The locomotives are to be prepared as described in preparation duties.

Each locomotive is equipped with three jumper couplings. When the locomotives are coupled for multiple unit operation, one set of jumper couplings are to be inserted between the locomotives. The brake pipe and main reservoir air hoses are to be coupled and all relative air hose cocks opened. When the locomotives are coupled and uncoupled, for multiple unit operation the jumper couplings are to be detached and replaced on the locomotive with the lowest number.

CONTROL AND BRAKE VALVE HANDLES

When operating with units in multiple unit consists, the control switch, reverser handle, automatic brake valve handle, and the independent brake valve handle should be in position on the appropriate equipment in the leading driver's cabin.

In the rear locomotive, the control switch must be turned off, and reverser key removed from the equipment and placed on the control desk. The motor generator sets must be left switched 'on'. The driver's brake valve isolating cock closed and the automatic and independent brake valve handle removed.

AMALGAMATION

1. Secure the stationary locomotive or locomotives by applying the independent air brake and hand brakes.

2. isconnect air hoses from dummy couplings on both locomotives. Remove safety hook from automatic coupler locking Lever and open automatic coupler jaw, see that both automatic couplers are in alignment. Ease up and, when coupled, test pull the couplings. Place the safety hook in the locking lever of the automatic coupler. Couple the brake pipe, main reservoir and number 3 and 4 independent air hoses and open the associated air cocks.

3. At the control stand being vacated, remove the independent brake valve handle, reduce the brake pipe pressure by 140 kPa with the automatic brake valve, close the brake valve isolating cock and remove the brake valve handle. Remove the reverser key and place control switch in the off position.

4. Obtain the three jumper couplings from the locomotive with the lowest number.

5. Insert the jumper couplings in their respective receptacles between the locomotives.

6. Test the operation of the pantographs from the leading locomotive.

7. Release the hand brakes applied at the beginning of the amalgamation.

8. When the amalgamation is complete, a check is to be made to ensure that there is no leakage on the air hose connections between the units.

DIVISION

1. Apply the hand brakes on the stationary locomotive or locomotives.

2. Close all air hose cocks between units.

3. Remove the three jumper couplings from their respective receptacles.

4. Place the three jumper couplings on the locomotive with the lowest number.

5. Remove safety hook from automatic coupler locking lever. uncouple the main reservoir brake pipe and number 3 and 4 independent air hoses after closing the air hose cocks. Reduce the brake pipe pressure on the stationary locomotive or locomotives by opening the brake pipe cock.

6. Ease up and uncouple. Attach the air hoses to the dummy couplers. Close the jaw of the automatic coupler and insert safety hook in the locking lever. Close the brake pipe cock.

STABLING

When the locomotive has been brought to a stand at the point of stabling the following duties should be carried out.

1. Place the automatic brake valve handle in the running position and the independent brake valve handle in the application position.

2. Apply both hand brakes.

3. Switch off the supply motor generator at the tumbler switch, on the driver's desk. Switch off compressors, heaters and lights.

4. Press pantograph lower buttons and lower pantographs.

5. Turn pantograph three-way cock to the down position, open the storage reservoir wheel valve and charge the storage reservoir. Close wheel valve tightly. Close the P & C reservoir inlet and outlet cocks.

6. Remove the reverser key and turn off control switch. Enter all defects in the Log Book.

7. When leaving locomotive, open battery switch, close all windows and doors.

DRIVERS, SPARE AND EMERGENCY EQUIPMENT

The following equipment shall be carried on 46 class electric locomotives:-

DRIVER'S EQUIPMENT

1 tail disc. In No.1 cabin.
2 cases of 12 detonators. One in each cabin.
2 red flags (in flag cases). One in each cabin.

FOR COUPLING TO ANOTHER LOCOMOTIVE

3 jumper couplings. In No.2 End Corridor.

TOOLS

1 spanner, hose M.R. & B.P.)
1 " " Bogie M.R.)
1 " " " B.Cyl.) In sealed box in
1 " " " Sand) No.1 end corridor.
1 pin punch)
1 chisel)
1 hammer)

SPARE AND EMERGENCY EQUIPMENT

1 air hose M.R.)
1 " " B.P.)
1 " " B.Cyl.) In sealed box in
1 " " Sand.) No.1 end corridor.
1 Rope 1220 mm)

2 fuses, main aux. H.T. 160 amp.) located on the end of
2 fuses, generator H.T. 40 amp) the regenerative elec-
2 fuses, compressor H.T. 18 amp) trical cabinet.

2 fuses, 100 amp, L.T.) located in the small
Generator & Battery) cabinet No.1 end.

1 kit bucket)
1 hook stick) In No.1 end corridor.
3 fire extinguishers)

RESISTANCE FANS AND MOTOR GENERATORS YELLOW INDICATOR LIGHTS

There is a yellow indicator lamp on each driver's panel for the resistance fan motors and for the motor generators. If this lamp is alight it indicates either that one of the motor generators has stopped, or that one of the resistance fans has stopped. If the lamp is alight when the accelerating handle is in the off position or in notch 20 position the indication is that one of the motor generators has stopped.

When operating in multiple unit consists the indicator light shines if a resistance fan or a motor generator on any locomotive is not operating.

Photo of Resistance Fan Control Panel

When the accelerating handle is moved to notch 1 the lamp will shine and stay alight for approximately one minute or until the accelerating handle is moved into Notch 20 or off position.

If it remains alight for more than one minute there is indication of trouble with the resistance fan motors or one of the motor generators.

In this case:-

(a) Check that both motor generators are running.
(b) Check that all eight fan circuits breakers on the low tension panels in the centre compartment are closed.

In summary, the yellow light will shine normally, when the motor generators are not running and the control circuit is complete. Under operating conditions with the motor generators running, the yellow light will shine as follows:-

(a) For one minute when resistances are in circuit - accelerating handle between 1 and 19 notch.

(b) Supply motor generator fails or is not producing current - battery charging is not taking place.

(c) Exciter motor generator fails or is not producing current.

(d) One or more of the resistance fan circuit breakers tripped.

(e) Supply motor generator 100 amp output fuse defective - battery charging contactor is open and exciter motor generator stopped.

(f) Switch group isolating cock closed.

TO TEST THE RESISTANCE FANS

1. Switch on motor generator sets.

2. Turn control switch off and then back on again to trip differential overload relay, so that power will not be applied.

3. Open accelerating handle to No.1 notch position.

4. After one minute the yellow light should be extinguished, indicating all resistance fans motors are running.

5. If the yellow light fails to go out check resistance fan motor (M.C.B.) miniature circuit breakers and if found to be tripped, reset the circuit breaker.

6. Check that fan motors are running, if found to be stopped, enter defect in the Log Book and bring under notice of the maintenance staff.

FAULTS, FAILURES AND THEIR REMEDY

The following is a complete coverage of the defects that may manifest themselves due to the malfunction or complete breakdown of equipment and the appropriate action required of the driver.

1. Lights will not go on when supply motor generator is not running. The following items are to be checked:-

   (a) Battery isolating switch is closed.
   (b) All miniature circuit breakers (M.C.B.) are 'on'.
   (c) Renew battery fuses.

2. Pantograph will not go up. The following items are to be checked:-

   (a) H.T. doors are closed and completely locked (two movements).

   (b) Control switch is 'on'.

   (c) Yellow light on the desk is showing. If not check the following items:

      (i) That lights operate.

      (ii) Main Control circuit breaker is on, No. 2 end.

      (iii) Auxiliary control circuit breaker is on, No. 2 end.

      (iv) Correct air pressure is available.

      (v) Pantograph isolating cocks are open.

(vi) If necessary, operate the pantograph raise magnet valve by hand.

(vii) Three way cock is in the correct position.

3. Line voltmeters do not register. The following items are to be checked:-

(a) Pantograph is up.
(b) Roof isolating switches are closed.
(c) If the line voltmeter is not registering a reading and power is available (indicated by motor voltmeter registering a reading) the locomotive may be operated normally. A suitable entry is to be recorded in the Log Book.

4. Compressors will not start. The train is to be brought to a stand immediately and secured by the application of sufficient hand brakes to hold it stationery.

The following items are to be checked:-

(a) Line voltmeter is showing a reading.
(b) Lights work from the low tension supply.
(c) Switch on supply motor generator. If supply motor generator runs, the 160 amp. aux. H.T. fuse is in good order, if not, renew 160 amp. fuse.
(d) Compressor control circuit breaker is on, No. 2 end.
(e) Compressor switches No.2 end.
(f) Compressor governor - check isolating cock is open. Operate latch on the side of the governor by hand if fails to operate normally, tie or wedge latch in the upwards position.
(g) 18 amp or 20 amp compressor fuses in No.1 H.T. compartment and renew if necessary.

5. One compressor only will not start.

(a) Check compressor switches are turned on.
(b) Renew 18 amp compressor fuses.

The locomotive may be operated normally, but a close watch must be kept on the main reservoir pressure.

NOTE: The compressors will not run at full speed unless the control switch is turned on.

The compressors will not start if the main reservoir pressure is above 700 kPa.

6. Failure of the supply motor generator. The following items are lost:

(a) One source of supply for low tension current.
(b) Battery charging
(c) Traction motor blowing and pressurisation of high tension compartments.
(d) Exciter motor generator.
(e) Resistance fans.
(f) Regenerative brake.
(g) Low tension cab heaters and hot plates.

The yellow light will shine on the driver's control panel, the battery charging is not taking place, and the ammeter will register a discharge. The following items of equipment are to be checked:~

(a) Line voltmeter is showing a reading.
(b) Lights work from low tension supply.
(c) Turn supply motor generator switch off and then switch it back on. This action resets auxiliary differential overload relay.
(d) Reduce main reservoir pressure and make compressors run: Providing the compressors run, the 160 amp aux. H.T. fuse is in good order, if not, renew the 160 amp fuse.
(e) Supply motor generator M.C.B. (No.2 end) is 'on'.
(f) Switch group isolating cock is open.
(g) Supply motor generator 40 amp fuse in No.1 H.T. compartment and renew if necessary.

If the supply motor generator is inoperative, the ventilating air to the traction motors is greatly reduced and care must be taken to avoid overheating the motors. In such conditions the average motor currents must not exceed the following values:-

700 amps for 30 minutes
550 amps for 60 minutes.
450 amps continuously.

If the load is such that the current exceeds these values the train must be placed in the first siding to avoid damage to the motors, and the locomotive worked light to a depot.

The regenerative brake and the resistance fans are inoperative.

7. Failure of the exciter motor generator. The following items are lost:

   (a) Resistance fans.
   (b) Regenerative brake.
   (c) 50% traction motor blowing and pressurisation of high tension compartments.

   The yellow light will shine on the driver's control panel. The following items of equipment are to be checked:-

   (a) Exciter control M.C.B. (No. 2 end) is 'on'.
   (b) Battery charging contactor.

   If the battery charging is not taking place, renew the 100 amp low tension supply motor generator output fuse.

   If the exciter M.G. is inoperative the average motor currents should not exceed the figures shown under failure of supply motor generator.

8. Resistance fan inoperative. The yellow light will shine on the driver's control panel.

   If both motor generators are running it is probable that one or more of the fan motors has stopped, and repeated accelerations will overheat the resistances.

   Check the resistance fan circuit breakers are not tripped. If found to be tripped reset the circuit breaker.

   If the defect cannot be rectified resistance should not be inserted during series regeneration.

   The resistances are designed to stand two successive starts each taking five minutes without the fans operating.

   If the fans are not operating and additional starts are required it may be necessary to wait for the resistances to cool down.

9. Wheel slip white indicator light and bleeper fail to operate when accelerating handle is moved to Notch 1.

   Check auxiliary control circuit breaker (No.2 end).

10. Sanders will not operate:-

    (a) Check auxiliary control circuit breaker (No.2 end)
    (b) Check that sander isolating cock is open.

11. Locomotive whistle will not operate.

    Check whistle isolating wheel valve, located below roof level, in each cab, and the whistle, main isolating wheel valve No. 2 cab.

12. Low tension cab, window and food heaters:-

    (a) Check that motor generator sets are running.
    (b) Check the respective circuit breakers, electrical cabinet, No. 2 end.

PROCEDURE WHEN LOCOMOTIVE WILL NOT MOVE OR LOSES POWER WHEN MOTORING OR REGENERATING

If on a steep falling grade, bring the train to a stand by applying the automatic air brake.

Return accelerating handle to "off" position and if using regenerative brake, the regenerative handle to the "MOT" position. Move reverser key to Forward Series.

Check control switch is in the 'on' position; Main Control 30 amp. M.C.B. No. 2 end; Control positive M.C.B. No. 2 end are not tripped and reset overload and overvoltage relays.

Take Notch 1 on accelerating handle.

If motor ammeter shows a reading electrical circuits are now normal, and the locomotive can proceed.

If motor ammeter does not read, return accelerating handle to 'OFF' and carry out the following checks to prove the locomotive supply circuits.

Check for	Supply is proved if:-	Action if no supply
1. OVERHEAD SUPPLY	Line Voltmeter reads or Motor Generators operate or Compressors operate	Ensure pantograph in contact with wire and pantograph isolating switches closed. If these are normal await restoration of power.
2. BATTERY SUPPPLY	Motor Generators operate or Compressors operate or Any loco lights operate	Check battery isolating switch is closed and battery fuses are not defective.
3. CONTROL CIRCUIT SUPPLY	Motor Generators operate or Unit switches operate or Indicator lamps light	Check main control M.C.B. is on. Supply motor generator M.C.B. is on. Unit switches operate. Indicator lamp lights.
4. CONTROL AIR SUPPLY	Motor Generators operate or Any unit switch operates	Check pantograph and contorl air gauge is registering 500 kPa. If not, ensure all isolating cocks are open. If the gauge is registering ensure switch group isolating cock is open.

OVERLOAD RELAY TRIPPING

Tripping of the overload relays will be indicated by lighting of the line switch indicator lamp, a sudden loss of power, and zero readings on both ammeters.

The M.G. sets will continue to operate and the line voltmeter will register.

The accelerating handle should be returned to the off position and the overload relay reset button pressed. The accelerating handle can then be notched up again carefully.

The overload relays should not be reset more than twice in succession.

After the tripping of the overload relays the locomotive should not be operated beyond full series for 1 minute, nor beyond series-parallel for a further period of 5 minutes.

When the overload relays have tripped twice in quick succession, the locomotive is considered to be a failure and the Maintenance Staff informed of the circumstances.

When operating in multiple unit consists, if the overload relays trip, the line switch red indicator lamp will shine on all units.

THE LINE SWITCH RED INDICATOR LIGHT

The line switch red indicator light will shine whenever the line switches are open with the accelerating handle in motoring and the control circuit complete.

In exception to the foregoing: When setting up for or going out of regenerative braking, the line switch red indicator light will shine, whenever the regenerative handle is opened and the accelerating handle is in the 'off' position.

When the accelerating handle is moved from the 'off' position, the line switches will open, causing the red light to shine, upon the following events occurring:-

1. Any one of the four protective relays operating.

2. Flat batteries - insufficient control current to close the unit switches.

3. Loss or low pantograph and control air pressure.

4. Switch group isolating cock closed.

5. Pneumatic control switch open - brake pipe pressure below 350 kPa.

6. Setting up and going out of regenerative brake (normal operation).

7. Pausing for more than one second between .off" and No. 1 notch position when opening the accelerating handle.

INTERRUPTION OF OVERHEAD SUPPLY

This will be indicated by loss of power and no reading on the line voltmeter. The line switches will open through the action of the no current relay which is de-energised on loss of line voltage and the red indicator light will shine.

Return the accelerating handle to the 'OFF' position and when power is restored, as indicated by the line voltmeter, and main reservoir air pressure has been restored, notch up again in the normal manner.

NOTE: If overhead power is not restored within two minutes, the instructions as outlined under Loss of Overhead Power must be carried out in their entirety.

INTERIM PROGRESS EXAMINATION FOR 46 CLASS ELECTRIC LOCOMOTIVE DRIVERS

1. What is electricity and what are the three effects?

2. How is it measured?

3. What is a generator?

4. What are the principal parts of a generator?

5. How is electro-motive force produced with a generator?

6. What is the purpose of a motor?

7. Describe the principle of a motor?

8. What is a fuse and what types are used on a 46 class locomotive?

9. Describe an open circuit, closed circuit, short circuit, an intermittent circuit.

10. Why and how is resistance used on a 46 class locomotive?

11. What is meant by:-

    (a) series,
    (b) series-parallel and
    (c) parallel combination of traction motors?

12. What is the purpose of the regenerative brake?

13. Describe the principle of operation of the regenerative brake.

14. (a) Name the high tension fuses in the auxiliary high tension circuit.

    (b) Name the fuses in the low tension circuit.

15. Trace the path of high tension current through the locomotive.

16. State what action is necessary before moving a locomotive into a bysiding

    (a) where current is normally switched on.

    (b) where current is normally switched off.

17. Describe the operation of the resistance fans:-

    (a) during motoring,
    (b) during regenerative braking.

18. Describe the operation of the three way cock for pantograph raising in each position.

19. If the supply motor generator fails,

    (a) what is lost,
    (b) what action is necessary to remedy the defect?

20. If the exciter generator fails,

    (a) what is lost,
    (b) what action is necessary to remedy the defect?

21. What is the purpose of the control circuit, indicate two (2) sources of supply to the control circuit.

22. What is the purpose of traction motor blowers and where are they located?

23. What is the purpose of:-

    (a) differential overload relay,
    (b) overload relay,
    (c) no current relay
    (d) over voltage relay.

    What action is necessary in the event of the relays tripping?

24. Explain the operation of the line switch red indicator light.

25. Explain the operation of the yellow light.

26. If a pantograph is damaged in service, what is the required action of the driver?

27. If the locomotive fails to make a correct transition change, what action is taken by the driver?

28. If the wheel slip light and bleeper fail to operate when the accelerating handle is moved to No.1 notch, what is the cause?

29. If the locomotive fails to move when the accelerating handle is opened and the red and yellow indicator lights are out, what is the cause?

30. What action is taken by the driver in the event of loss of overhead power?

31. What type of brake is fitted to the 46 class locomotive?

32. What is the compressor arrangements?

33. How are the compressors controlled in output?

34. In addition to air brake needs, what else is supplied from the compressors?

35. What is the function of the distributing valve?

36. Describe the principal parts of the distributing valve.

37. What happens when the driver's automatic brake valve handle is placed in the lap position?

38. If one compressor fails what action is taken?

39. If both compressors fail what action is necessary?

40. How can the defects be traced and remedied?

41. What action is necessary in the event of a vigilance control penalty brake application?

42. What action is necessary if it cannot be reset?

85 CLASS ELECTRIC LOCOMOTIVES

85 CLASS LOCOMOTIVES

GENERAL DESCRIPTION

The 85 class electric locomotive is employed in the haulage of freight and passenger trains over the various lines within the electrified area. General particulars are as follows:-

Voltage	1500 D.C.
Wheel arrangement	CO - CO
Mass	120 tonnes
Axle load	20 tonnes
Wheel diameter	1250 mm
Bogie Wheel base	4000 mm
Total wheel base	14400 mm
Length over buffers	19000 mm
Overall width	2883 mm
Height from rail level to pantograph lowered	4330 mm
Horse power	2700 kw
Maximum speed	100 km/h
Low tension supply	120 D.C.
Dead hauling mass	125 tonnes

Cab

The locomotive has a driving position at each end with suitable accommodation for the enginemen.

Housed within the locomotive is the control equipment traction motor blowers, starting resistances, blower fans and motor alternator set.

Two electrically driven compressors are mounted on the underframe also the battery charger and batteries.

Traction Motors

There are six (6) traction motors, three on each bogie giving traction on all wheels. Each traction motor is supported by axle suspension bearings. A lateral hydraulic snubber is provided on the bogie located adjacent to the inner axle. The introduction of this type of snubber should improve riding characteristics. In addition, two traction snubbers are used to control swivelling of the bogie.

Shrunk onto the motor armature shaft is a pinion that meshes with a drive gear pressed onto the driving axle. The gear ratio between the pinion and the drive gear is expressed by two figures, such as 79/20 for the 130 km/h gearing used on this locomotive. The first number indicates the number of teeth on the drive gear and the second the number of teeth on the pinion.

Armature bearings are of the roller type and axle suspension bearings are also roller bearing type.

Control Equipment

The control equipment is arranged for the motors to be connected either six in series, two paralled circuits each of 3 motors in series, or three parallel circuits each of two motors in series. Four weak field positions are provided in each combination. Contactors are of the electro-pneumatic type.

Resistances are of strip metal type. They are provided with blowers which come into operation when the resistances are in circuit for over a prescribed time.

Provision is made for regenerative braking in series and series-parallel.

The control voltage is 120 D.C.

Batteries

The batteries consist of 54 cells of the lead acid type with a capacity of 55 amps hours.

The battery switch being a double pole knife type located on the upper portion of the circuit breaker panel.

Motor Alternator (MA) Set

The motor alternator (MA) set produces three phase 415 volts of current for the operation of the traction motor blowers, starting resistance fan motors, hot plates, cab heaters, air conditioning and alternating current (AC) control apparatus. Portion of this current is rectified to 120 volts DC for operation of the control circuit and battery charging.

A separate three phase supply is provided by the motor alternator for regenerative braking.

The control circuit of the motor alternator (MA) set is protected by the motor alternator control circuit breaker (M.A.C.B.) located on the circuit breaker panel and it is essential that it be "on" to permit continuous operation of the motor alternator while ever the locomotive is in service.

High tension current from the overhead drives the machine and protection is provided by the Differential Current Detector and overcurrent relay (M.A.O.C.R.) through the operation of the High Speed Circuit Breaker.

The three phase 415 volt output has an overvoltage protector and in addition is protected by the alternator current (AC) circuit breaker located on the wall adjacent to the alternator.

Regenerative brake excitation supply is protected by three large fuses bolted to the wall adjacent to the motor alternator and are not to be renewed by enginemen.

Should a defect develop on the motor side of the alternator, the motor alternator overcurrent relay (M.A.O.C.R.) will operate and trip the High Speed Circuit Breaker, isolating the 1500 volt overhead supply to the motor alternator. Similarly, an overvoltage relay (OVD) protects the output side of the motor alternator and should a defect develop, OVE) energises the motor alternator overvoltage relay (M.A.O.V.R.) which de-energises the motor alternator contactor (MAC). This interrupts high tension current supply to the motor alternator and upon it being stopped, the alarm circuit is energised.

Operation of the motor alternator overcurrent relay (M.A.O.C.R.) will cause both the blue and red lights to shine and the alarm bell to sound.

The tripping of the overvoltage relay (M.A O.V.R.) will cause the motor alternator output to be interrupted, the blue light will shine and alarm bell will sound.

The motor alternator overcurrent relay (M.A.O.C.R.) and M.A.O.V.R. are reset and the warning lights and bell cancelled by operating the fault reset button on the driver's stand.

Supply Isolate Switch (SIS)

This switch is located on the circuit breaker panel and is normally on. Should a defect develop or it becomes necessary to isolate the motor alternator for any reason, the switch is to be turned "off". This action also isolates the blue light and bell.

Supply Indicating Relay (SIR)

This relay is located on the 120 volt side of the battery charger and operates the blue light and alarm to indicate that the output from the alternator is lost, due to the motor alternator (AC) control circuit breaker, battery charger circuit breaker (BACB) or supply indicator circuit breaker (SIRB) tripping out.

Under normal circumstances, the blue light and bell will be cancelled when the circuit breaker is reset.

Remote Supply Circuit Breaker

If the batteries are discharged to the point where the auxiliary machines cannot be started provision is made in the jumpers to obtain a 120 V remote supply from a battery charger to another 85 class locomotive. This is connected when jumper couplings are inserted and Remote Supply circuit breaker (RSB) seal is broken and switched "ON" on both locomotives. The operation of the circuit breakers will cancel the "Failed Alternator" indication and alarm by energising the "Supply Indicating relay" (S.I.R.)

Once the auxiliary machines are started the "Remote Supply Circuit breakers" on both locomotives must be opened and the defect recorded in the log book.

Note: In the event of the motor alternator failing on a locomotive in a multiple consist, control circuit current (120 volt) can be obtained by adopting this procedure but in all cases the control circuit cut out switch (CCOS) must be located in the "off" position on the locomotive with the failed motor alternator. In addition, lower pantographs and turn off supply isolating switch (SIS).

External Alternating Current (AC) Power Supply

An external alternating current (A.C.) Power supply socket is mounted on the underframe at No. 1 end of the locomotive and a sequence testing switch mounted in the

electrical cabinet. This is used by the maintenance staff to test the locomotive without having the 1500 V supply.

This switch should be carried in the "Normal" position.

NOTE: The sequence test switch controlling supply is next to the control circuit cut out switch (CCOS) in the electrical cabinet.

COMPRESSORS

There are two air compressors each having a displacement of 2 cubic metres per minute and each is driven by a 1500 volt motor.

BRAKE EQUIPMENT

The locomotive is equipped with automatic 26L Self lapping, brake pipe pressure maintaining, type of brake equipment. This system functions by employing the same 4 pipe arrangement as applies for the A7-B7EL type i.e. the locomotive pipes are designated Brake Pipe, Main Reservoir, Control and Independent Release. Thus it functions in conjunction with, and under control of, other locomotives fitted with A7-B7EL systems both in the automatic and independent aspects.

Main Reservoir Drain Valves

Automatic drain valves are fitted to the main reservoir and under normal conditions will drain all water from the main reservoirs. However, should the air valve not seat effectively air will escape from the opening in the base.

If loss of main reservoir pressure in service occurs and it is found to be due to this cause the body of the valve may be lightly tapped to reseat the valve.

MOTOR COMBINATIONS

Each locomotive is equipped with six traction motors which are axle mounted. Motors Nos. 1, 2 and 3 are on one bogie and motors Nos. 4, 5 and 6 on the other bogie.

Powering circuit

(a) Series connection

The six traction motors and two groups of starting resistances are connected in series.

The starting resistance is cut out step by step by the resistance camshaft under current limit control.

(b) Series-Parallel connection

The traction motors are connected into two parallel groups each group with three traction motors in series. The two resistance groups are connected in parallel.

(c) Parallel connection

The traction motors are connected in three parallel groups with two traction motors in series.

The two resistance groups are connected in parallel.

(d) Field weakening

Can occur in each motor grouping. There are four steps of weak field. All motors are connected for maximum weak field at starting.

Line Volt Meter

A line volt meter is located at roof level in the left top corner of the driving cab and indicates the overhead line voltage.

Control Circuit Cut Out Switch (CCOS)

The control circuit rotary cut out switch is located in the Electrical Cupboard and is labelled "ON" and "OFF"

In the "ON" position normal operation is available but in "OFF" position the power circuit for traction motor operation is isolated, together with the red fault light and alarm bell.

However, the placing of the control circuit cut out switch (CCOS) does not prevent the control circuit from being operated by the accelerating handle, regenerative handle and reverser on the isolated locomotive, which permits power to be applied on trailing locomotives from the leading locomotive when it is "dead".

Supply Isolate Switch (SIS)

This switch is located on the circuit breaker panel and is labelled "ON" and "OFF".

When moved to the "OFF" position it isolates the motor alternator and also the alarm circuit; blue light and bell.

LOAD METER (AMMETER)

The load meter is of the centre zero type, clockwise motoring, and anti-clockwise regen brake with a continuous rating zone extending up to 690 amps and an overload zone coloured red for both motoring and when operating in regenerative brake. One hour rating under full power is 725 amps.

CONTROL CIRCUIT

The control circuit consists of battery charging, control and small motor circuits, contactor and relay coils, lighting circuits and air conditioning.

The control circuits are protected from overload by numerous magnetic circuit breakers and fuses.

A magnetic circuit breaker protects the circuit from an overload of current in a similar manner to a thermal type. It has a magnetic coil and spring loaded armature plate incorporated in the switch.

When the amperage exceeds the value of the circuit breaker, the magnetic coil overcomes the tension of the spring and moves the armature plate sufficiently, to permit the switch to trip off and open the circuit. The toggle portion of these switches displays a white band which provides a positive indication of whether the circuit breaker is switched 'on' or 'off'

Powering Switch

In the "on" position the control circuit completes the traction circuit when power is applied and in the "off" position, the traction power circuit is interrupted.

Therefore, it is essential that this switch be "on" at the driving location and switched "off" in trailing locations.

Note: With this switch "off" the Motor Alternator will not run and line switches will not close to complete the power circuit.

(Blank Page)

Photo of Battery Charging and Fuse Panel

BATTERY FUSE PANEL

The battery fuse panel, located adjacent to the battery boxes, contains the following equipment:-

(a) three (3) battery fuses.
(i) 60 amp battery positive fuse (BPF)
(ii) 60 amp battery negative fuse (BNF)
(iii) 60 amp spare fuse

(b) three (3) auxiliary fuses.
(i) 10 amp auxiliary positive fuse (ALPF)
(ii) 10 amp auxiliary negative fuse (ALNF)
(iii) 10 amp spare fuse

(c) a fuse tester

The auxiliary fuses protect the two fuse testers, the one located within the battery fuse panel and secondly the fuse tester located within the high tension compartment.

During preparation, the spare fuses are to be tested in the following manner:-

1. Operate light switch to ensure light bulb functions.

2. Turn off light switch.

3. Lay fuse to be tested across the test block.

If the fuse is good the light should shine.

In the event of the fuse test light not functioning, check the globe is not defective and renew the defective fuse with the spare provided.

DRIVER'S DESK

It is located directly in front of the driver and is equipped with the following:-

1. Two air brake pressure gauges.
2. Flowmeter.
3. Loadmeter (Ammeter).
4. Pan up buttons front and rear.
5. Pan down buttons front and rear.
6. Headlight switch (3 positions).
7. Wheelslip/slide alarm - White light.
8. Brake cylinder pressure - Blue light.
9. Reset button.

10. Failed Fan - Amber light.
11. Resistance notch - Amber light.
12. Resistor overheat detector - Amber light.

Control Panel

1. Timetable light. 2. Panel light.
3. Powering Switch. 4. Cab light.
5. Vigilance control button. 6. Demister.
7. Cab heater 1. 8. Cab heater 2.

Observer's Panel

1. Power Fault light - Red light.
2. Alternator failure - Blue light.
3. Step light toggle switch.
4. Marker light.
5. Marker light.
6. Cab light.
7. Panel light.
8. Cab heater 1.
9. Cab heater 2.

In addition, windscreen washers and wiper controls are provided for both the driver's and observer's position.

Alarms and Safeguards

The locomotive is equipped with the following alarms and safeguards.

1. An alarm bell and buzzer are provided to warn the driver that one of the safeguards has operated.

2. Coloured lights indicating the various troubles that can occur in conjunction with the ringing of the alarm bell located at each driving position and are as follows:-

Power Fault Indicating Light (PFIL)

Red light and bell operates if any of the following occurs:

(a) Fault in traction circuit.
(b) Overcurrent in traction motors (straight overload operation 1400 amperes).
(c) Overcurrent on motor side of motor alternator (high tension).

(d) Opening of the control governor.
(e) Overvoltage relay tripped out (2050 volts).
(f) Failure in camshaft control to respond correctly.

Faults a, b, c, d cause the high speed breaker to open and this opens the line switches which will also cause the blue light to shine.

Faults e, f, only cause line switches to open.

When the (PFIL) Red power fault indicator light operates under power return the accelerating handle or regenerating handle to the "OFF" position and press the fault reset button.

In the event of the motor alternator stopping the Blue Failed Alternator light (FAL) will also shine.

NOTE: There is a time (delay of up to fifteen (15) seconds from the time the reset button is pressed until alarm ceases.

FAILED MOTOR ALTERNATOR (MA) SET

The blue light will shine and alarm bell will sound in the event of output from the motor alternator being lost.

In addition the blue light will shine and alarm bell sound in accordance with the following:

(i) Motor alternator (AC) control circuit breaker tripped.
(ii) Battery charger circuit breaker (BACB) tripped.
(iii) Supply indicator circuit breaker (SIRB) tripped.
(iv) Main alternator supply breaker (ACB) tripped.

Under normal circumstances, the blue light and bell will be cancelled when output supply is restored by the resetting of the circuit breaker.

Motor Alternator (MA) Set Fails with both the Blue and Red Lights Shining and Alarm Bell Sounding

This indicates a fault on the high tension side of the motor alternator and the probable cause is the motor alternator overcurrent relay (MAOCR) has operated and tripped the high speed circuit breaker causing the line switches to open and isolating the 1500 volt overhead supply, which will stop the motor alternator.

To reset the motor alternator overcurrent relay (MAOCR) operate the fault reset button on the driver's control stand. This will cancel the red light and immediately the motor alternator commences to produce current the blue light and bell will cease to function. A time delay of approximately fifteen (15) seconds applies.

Wheel Slip/Slide Indicator Light - White light and buzzer operates if either of the above occur.

When powering the armature current is reduced to the affected wheel and automatic notching stops until wheel slip is corrected. The tractive effort should be reduced by easing the accelerating handle toward minimum position in notch 4 as well as operating the sander button if continual slipping is experienced.

When operating in regeneration, the braking effort will automatically be reduced. When continual wheel slide is experienced, the regenerative handle position should be adjusted to correct the slide.

When the wheel slip/slide occurs during pneumatic braking no automatic correction is effected and braking effort should be reduced in conjunction with sanding.

If continual wheel slip/slide is indicated a check must be made to ensure all wheels are capable of rotating freely. If not the unit must be isolated and considered a failure.

Brake Cylinder Pressure - Blue Light

The brake cylinder pressure blue light is provided to warn the Driver should the brakes inadvertently apply on the locomotive or on any trailing locomotive fitted with this switch in a multiple unit consist. The light is normally extinguished while ever the brakes are released.

When pressure in the brake cylinder rises to 30 kPa, the switch closes and the blue light shines. Upon the pressure falling to 10 kPa, the switch opens, the blue light is extinguished.

The brake cylinder pressure blue light is train lined through the jumper coupling and will shine on all locomotives, when the brakes are applied on one or more of the locomotives in a multiple unit consist.

Brake Cylinder Pressure Blue Light Shines

The blue warning light will shine whenever the brakes are applied and pressure in the brake cylinders exceeds 30 kPa.

Should the blue warning light shine when the locomotive(s) are being operated with the brakes released, immediate action is to be taken to release the brakes in accordance with current instructions.

NOTE: This particularly applies in a multiple unit consist as severe damage can be caused to a trailing locomotive due to the brakes failing to release from a slight overcharge of the brake pipe.

Failed Fan Alarm - Amber light and bell

Power circuit is interrupted automatically. The failed fan alarm will operate in the event of a resistance or traction motor blower fan stopped, due to a fan circuit breaker tripping or contactor failing to close.

Move the accelerating handle to the "off" position and check resistance fan and traction motor blower circuit breakers are not tripped.

When necessary reset a tripped circuit breaker and operate the reset button at the side of the electrical cupboard adjacent to the Emergency Light Engine Switch - labelled fan reset.

Should the circuit fail to reset, the alarm will continue to operate and it will be necessary to move the Emergency light locomotive switch to the "Emergency" position to restore power on the locomotive.

Resistance notch indication - Amber light

This light shines on all units when the accelerating handle is opened and will continue to shine until all resistance is notched out of circuit by the automatic action of the camshaft; i.e., the light shines to indicate to the driver that resistance is in circuit and continuous operation of this light beyond a reasonable time period will require attention to determine the cause.

It is important to note that forward transition cannot be achieved while the amber light is shining with resistance remaining in circuit.

Thermal overheat device is a protective device and operates if any excessive overheating occurs within the starting resistances.

Resistor overheat alarm - amber light and bell

Power circuit is interrupted automatically. The amber resistor overheat alarm will operate to indicate overheating of the resistances and under normal conditions should be able to be reset within a period of three (3) minutes by moving the accelerating handle to the "off" position and operating the reset button adjacent to the Emergency Light Locomotive switch at the side of the Electrical Cupboard labelled "fan reset".

Should the resistor overheat circuit fail to reset after the reset button has been operated a number of times and a period of not less than five (5) minutes has elapsed, then the Emergency Light Locomotive Switch is to be moved to the "emergency" position.

When the Resistor overheat circuit operates it is of the utmost importance that it is recorded in the log book and the maintenance staff fully informed of the circumstances at the depot at the termination of the run.

If the resistor overheat operates more than twice in starting, then arrangements are to be made to stow the train and remove the locomotive from service as quickly as possible.

MASTER CONTROLLER

The Reverse lever, Powering handle and Regenerative braking handle are assembled in the master controller.

1. Reverser Lever

The Reverse lever has four positions:-
Forward, Off, Reverse and Isolate.

Direction in which the locomotive moves is controlled by placing this lever in the desired position.

The Reverse lever should be moved ONLY when the locomotive is standing still.

The Reverse lever can only be inserted and removed from the master controller horizontally in the "Isolate" position.

The Reverse handle can be moved only when the Powering handle and the Regenerative brake handle are placed in the "OFF" positions.

Removal of the Reverse lever locks the operating controls of the master controller.

When operating the locomotives in multiple unit, the Reverse lever should be removed from the master controller in all the cabs except the driving location.

The Reverse lever is also used for operating the interlock mechanism of the entrance door of the high tension compartment.

2. Powering Handle

The Powering handle has six positions:-

OFF
POSITION NO. 1 (NOTCH DOWN)
POSITION NO. 2 (HOLD)
POSITION NO. 3 (NOTCH UP)
POSITION NO. 4 (RUN UP)
POSITION NO. 5 (TRANSITION)

The position of the powering handle is indicated by the illuminated indicating plate visible from the upper side of the master controller.

The powering motor current and the motor connection in powering is controlled by the operation of this handle.

The powering handle can be operated only when the Reverse lever is in Forward or Reverse position and the Regenerative braking handle in the "OFF" position.

Positions 1, 2, 3 are used for low speed operations and permit resistance to be inserted or deleted in "series" to achieve desired speed as follows:-

Position 1 (Notch down) When the powering handle is located in this position and returned to position 2, resistance is inserted in circuit.

Position 2 (Hold) This position is used when desired speed is achieved and during notching operation.

Position 3 (Notch Up) This position is used to achieve an increase in speed. By alternating the powering handle between position 3 and 2 positions the desired locomotive speed is attained. Each time the handle is placed in position 3 (notch up) and returned to position 2 (Hold) a bank of resistance is deleted. In this position when all resistance is out of circuit and the amber notching light is extinguished the weak field notches may be used. A series of ten (10) starting resistances are provided therefore ten (10) separate notching movements can be made in the low speed notches plus four weak field notches.

Position 4 (Run Up) This is the normal operating position and gives the operator flexible control in each combination.

Position 5 (Transition) This position is used to achieve forward transition when the powering handle is momentarily placed in this position transition is effected when the notching light is extinguished. The accelerating handle should then be placed in position 4 to give flexibility of control.

3. Regenerative Braking Handle

The Regenerative braking handle has two positions "OFF" and "REGENERATIVE BRAKE".

The Regenerative braking handle can be operated only when the Reverse lever is in the forward position and the powering handle is in the "OFF" position. There is a hump guide between the "Off" and the Regenerative brake positions.

The Regenerative braking effort is controlled according to the angle position of the regenerative braking handle.

The detailed function of the Regenerative brake is described under "Operating procedure".

Regeneration Brake Control

Regenerative braking can only be used if the reverser handle is in the forward position.

The braking range is set to provide maximum to minimum braking provided the current and weak field ratio limits are not exceeded to cause unstable traction motor operation.

The maximum armature current limit of 900 amperes in braking is gradually decreased to 690 amperes automatically during a time interval of ten (10) minutes to prevent overheating of the traction motors. From the above it will be noted that the braking effort will be gradually reduced after the initial application even though the regenerative braking handle is in a fixed position.

The current limit is reset to 900 amperes by moving the regenerative handle to "OFF" position and back to regeneration zone.

Selection of either series or series-parallel under regenerative braking is automatically controlled and dependent on speed; up to 55 km/h series and above this speed series-parallel combination. When speed falls below 35 km/h and regeneration was initiated in the series-parallel combination and braking is to continue, then series combination is to be selected. This is achieved by shutting off regenerative braking and then re-applying whilst travelling at the slower speed.

A voltage polarity detector (VPD) is provided to detect that the voltage of the armature circuit is higher than the overhead supply voltage before closing the line switches to commence braking.

This detector monitors the output voltage of the traction motors and compares this voltage with the voltage of the overhead supply.

When a difference of 100 volts D.C. is detected with the motor voltage being the higher of the two voltages the contactors close and current will commence to flow from the traction motors to the overhead.

MAIN ISOLATING SWITCH

It is necessary for this switch to be closed for any of the 1500 volt equipment to operate. The switch is interlocked with the doors of the high tension compartment so that the switch cannot be closed unless the doors are closed, and the doors cannot be opened unless the switch is open, and the equipment earthed.

The switch is unlocked by inserting the reverser handle in the "Power On" position.

Move reverser handle to "handwheel unlocked" position.

Photo of Pantograph isolating switches

Turn handwheel through full movement in direction of arrows.

Move reverser key to "door unlocked" position and remove.

To lock door reverse above procedure.

MANUAL PANTOGRAPH ISOLATING SWITCHES

Manual pantograph isolating switches are located inside the high tension compartment and enable individual pantographs to be isolated under emergency conditions. The rotation of the spider wheel opens the pantograph knife switch, isolating the pantograph from the rest of the locomotive.

The manual pantograph isolating switches have been burnt through interference with the spider wheels in the high tension compartment.

To eliminate this problem, the maintenance staff will fully close the isolating switch and seal them.

Should it be necessary for the pantograph to be isolated under emergency conditions, then enginemen may break the seal and operate the spider wheel concerned. A suitable entry must be recorded in the log book.

NOTE: In the case of the locomotive becoming derailed, enginemen are reminded it is dangerous to touch any part of the framework of the car or bogie, unless the pantograph is in the lowered position and clear of the overhead wiring. If the pantograph cannot be isolated from the overhead wire the manual isolating switches should be operated to the "Open" position.

JUMPER COUPLING

The locomotive is equipped with a permanently attached 42 pin jumper coupling and receptacle.

The 42 pin jumper coupling is removed from its dummy receptacle by turning a small wheel anti-clockwise to withdraw a threaded screw, thus releasing a locking clamp and freeing the jumper head.

When placing the jumper coupling in position its face must be located with the matching lugs in the receptacle. The locking clamp is then lifted upwards and secured in position with the small hand wheel being turned clockwise moving the threaded screw in to secure it.

These jumper couplings must be secured to the dummy receptacles and not left hanging loose as they are dangerous in this condition and can cause serious injury to personnel as well as damage to the equipment.

When removing and inserting jumper couplings Reverse handle should be located in "Isolate" position to reduce possibility of injury and burning of contact points.

The receptacle is fitted with a shear pin designed to permit the jumper coupling to be released and avoiding damage to equipment in the event of train being parted. Particular attention should be paid to the shear pin during preparation and if defective should be rectified prior to departing from the depot.

Jumper Wiring

Pin No.	Wire No.	Function
1	1	Forward
2	2	Reverse
3	3	Powering
4	4	Run UP
5	5	Regenerative Series-Parallel
6	6	" Brake
7	7	Transition
8	8	Fault
9		Spare
10	10	Overload, overcurrent and HB reset
11	11	Pan Up No. 2 end
12	12	Pan clown No. 2 end
13	13	Brake cylinder pressure indicator
14	CP	Control positive
15	15	Pan Up No. 1 end
16	16	Pan Down No. 1 end
17	BN	Battery negative
18		Spare
19	CP	Control positive
20	20	Sanding control
21	20	" "
22	22	Compressor synchronising
23	CP	Control positive
24		Spare

(Blank Page)

Photo of High Speed Breaker

Pin No.	Wire No.	Function
25	CN	Control negative
26	CN	Control negative
27	27	Wheel slip
28	28	Remote supply
29	28	" "
30	RT/1	Regenerative brake pattern voltage
31	RN/1	Regenerative brake negative
32	CN	Control negative
33	VPN	Current pattern negative
34	BN	Battery negative
35	BN	" "
36	A	Notch advance
37	H	Notch hold
38	B	Notch back
39		Spare
40	40	Resistance notch indicator
41	VP1	Powering current demand
42	VP2	Regenerative brake demand

Note: No. 1 and 2 wires are crossed between junction boxes.

HIGH SPEED CIRCUIT BREAKER

The high speed circuit breaker (HB) is provided on the locomotive to protect the high tension powering circuits and the motor circuit of the motor alternator, should a fault develop.

The circuit breaker operates at a high speed and is capable of opening the high tension circuits when fault currents of up to 50,000 amperes flow.

The circuit breaker incorporates three operating coils:-

(a) A 'RESET' magnet valve for the initial picking up of the circuit breaker. This magnet valve is only energised while ever the overload reset button is pressed.

(b) A 'HOLDING' coil, this coil holds the circuit breaker closed when the overload reset button is released and thirdly,

(c) A 'TRIPPING' coil or "Bucking Bar" which causes the circuit breaker in the event of a fault in the high tension to trip.

Location

The high speed circuit breaker is located in the high tension compartment adjacent to the main and vernier camshaft group.

Operation

The high speed circuit breaker is closed by pneumatic action when the high speed circuit breaker 'RESET' magnet valve is energised. The 'RESET' magnet valve energises when the overload reset button (ORB1 or 2) on the driver's instrument panel is pressed, and the reset relay (RSR) operates and closes its contacts which are in series with the high speed circuit breaker 'RESET' magnet valve.

To maintain the circuit breaker in the closed position once the overload reset button is released, a holding coil located within the circuit breaker is energised.

In series with the holding coil are normally closed interlocks of overload relays OLR1, OLR2 and OLR3, motor alternator over current relay MAOCR and the differential relay DFR. If any of these relays trip, the holding coil will de-energise and the high speed circuit breaker will open.

In order to again close the circuit breaker, it is necessary to reset the tripped relays by pressing the overload reset button.

The tripping coil incorporated within the circuit breaker detects excessive current flowing through the circuit breaker and causes the circuit breaker to trip.

No Volt Relay (NVR)

This relay is provided to prevent a re-application of power to the traction motors in the event of a loss of overhead current when power is restored. When this relay operates it is necessary for the operator to return the powering or regeneration handle to the "Off" position to reset the No Volt Relay.

This relay will close when 1100 volts is present in the overhead and will open if overhead falls below a predetermined point.

Differential Current Detector in case of a fault on the 150OV equipment the locomotive is provided with a differential current relay which will trip the high speed breaker and open the line switches.

Overload Relays (OLR1, OLR2, OLR3) The overload relays trip if the current flow to the traction motors exceeds 1400 amperes.

The Differential Current Detector trips if the amount of current flowing into the circuit is different from the amount flowing out. This indicates an earth fault in the equipment.

The differential and overload relays are reset by first returning the powering or regeneration handle to the "off" position and then by pressing the fault "Reset" button on the driver's stand.

They should not be reset more than twice in quick succession. Repeated settings will damage the equipment and may result in a fire.

When the powering or regeneration handle is in the open position the tripping of the overload relays and differential current detector is indicated by the presence of the Red Power Fault indicator light on the affected unit and the alarm bell on all units in multiple.

Overvoltage Relay (OVR)

This relay is energised during regeneration and opens the line switches if the voltage which is being generated exceeds 2050 volts. It is reset by returning the regenerative handle to the "OFF" position.
Indication Red "Power Fault Indicator" light on affected locomotive, Alarm bell on all units in multiple.

AUXILIARY RELAYS, AR 1 AND 2

Two auxiliary relays are mounted at each end of the locomotive adjacent to the respective "Pan Up" and "Pan down" magnet valves.

An auxiliary relay (AR) must be energised before the no volt auxiliary relay (NVAR) will operate and energise the motor alternator contactor (MAC) and Compressor

Contactor (CC) permitting these auxiliary machines to operate. At the same time the fault alarm circuits also become operative when the "Pan up" button is pressed and Auxiliary relays (AR) energised.

When the "Pan down" button is pressed, the Auxiliary relays (AR) are de-energised, opening the motor alternator contactor (MAC) and Compressor Contactor (CC) before the pantographs leave the overhead wire.

This ensures that current is not flowing from the overhead wire to the pantograph and prevents any arcing that may damage the pantograph strips or contact wire due to the auxiliary machines operating.
NOTE: When stabling both Pan down buttons must be pressed.

AIR COMPRESSORS

The air compressors are driven by 1500 volt electric motors and are controlled in output by an electro-pneumatic governor.

In order for the compressor contactors CC1 and CC2 to operate the following circuit breakers and switches must be turned on:-

(a) Train Control Circuit Breaker (TCB). This is located on the main circuit breaker panel.

(b) Compressor Circuit Breaker (CMCB). Also located on the main circuit breaker panel.

(c) Compressor Control Switches CMS1 and CMS2. These rotary switches are located in the top-right hand side of the electrical compartment.

The compressor control circuit is fed through the compressor motor circuit breaker and a compressor governor synchronising circuit breaker is also provided on the circuit breaker panel.

The compressors are under the direct control of the governor, which is of the square "D" type, located on the bulkhead of the machine compartment. Each compressor may be stopped and started through individual compressor switches behind the right hand door of the electrical cabinet. The compressor motors are protected individually by a high tension 20 amp fuse mounted on the panel in the high tension compartment.

One (1) spare compressor 20 amp fuse is provided for replacement purposes.

PANTOGRAPH CONTROL

The pantographs are raised by main reservoir air pressure when available. If air pressure is not available a footpump is supplied at each end of the locomotive and after pressing "Pan up" button or manually operating the "pan up" and AR set plungers the respective footpump should be operated till the pantograph makes contact with the overhead wire the compressors commence to run and sufficient air is available to maintain contact between pantograph and contact wire.

In the air supply pipe line to the pantograph cylinders there is an isolating cock which is connected to the interlocking mechanism for the door of the high tension compartment. This cock is enclosed in the High Tension (H.T.) door interlock and prevents the pantographs being raised until the door is closed and locked.

A two position vented isolating cock is located at each end of the locomotive adjacent to the pantograph magnet valves which isolates the air supply to the respective pantograph roof cylinder when the handle is placed horizontally and is to be used to ensure the pantographs cannot be raised accidentally when running under dead sections of wiring.

TRACTION MOTOR BLOWERS

Two traction motor blowers are provided, one at each end of the machine compartment and are driven by 415 volt 3 phase power from the motor alternator (MA) set.

Protection is incorporated in the traction motor and resistor blower fan motor circuits against overheating. If the fan motor contactors are not closed within sixty (60) seconds this is detected by interlocks on the contactors, the failed resistor blower fan amber light and alarm bell operates and power is automatically interrupted for a period of three minutes.

When the Resistor overheat circuit operates it is of the utmost importance that it is recorded in the log book and the maintenance staff fully informed of the circumstances at the depot at the termination of the trip.

Control of Resistance Cooling Fan Motors

Resistance cooling fan motors cool the starting and vernier resistances. Ten (10) seconds after power is applied Nos. 1 and 2 cooling fans start. After a further five (5) seconds Nos. 3 and 4 cooling fans start. If all resistances are cut out within ten (10) seconds the fans do not start.

The cooling fans stop three minutes after power is removed from the starting and vernier resistances.

If any cooling fan contactors fail to close or resistor blower circuit breaker trips, the line switches are opened automatically within sixty (60) seconds and reapplication of power is stopped for three (3) minutes. The failed fan amber light will shine and alarm bell will sound.

If the resistor overheat operates more than twice in starting, then arrangements are to be made to stow the train and remove the locomotive from service as quickly as possible.

Starting and Vernier Resistances

A series of ten starting resistances are provided (in two banks) with suitable blower fans for cooling purposes. Under normal operation an amber resistance notching light will shine while resistance is in circuit during notching. In multiple unit operation the amber light remains on in all units when any of the locomotives are powering with resistances in circuit.

Control of Resistance Cooling Fan Motors

Prevention of damage to the resistances by excessive heat is effected by the provision that if the resistance blower fan motors fail to start up within sixty (60) seconds, then the alarm circuit, amber failed fan light and bell are energised and power circuit interrupted for a period of three minutes.

A thermal overheat device is provided in the resistance compartments to detect any excessive heating. Should the thermal overheat device operate then the alarm circuit amber overheat light and bell are energised and the power circuit is interrupted until the temperature is reduced in the resistance compartments. Under these circum-stances it is necessary to wait until the resistances

cool down and an additional period of 180 seconds to elapse when the alarm bell ceases to function, which may take up to fifteen (15) minutes.

When necessary to reset a circuit breaker it is also necessary to operate the reset button at the side of the electrical compartment adjacent to the emergency light engine switch - labelled fan reset.

Should the resistor overheat circuit fail to reset after the reset has been operated a number of times and a period of not less than five (5) minutes has elapsed, then the Emergency Light Locomotive Switch is to be moved to the "Emergency" position.

Failure of Traction Motor Blowers or Resistance Blower Fans

In the event of the failure of a traction motor or resistance blower fans the power circuit is interrupted automatically. The failed fan alarm light and bell will operate.

Move the accelerating handle to the "OFF" position and check resistor fan and traction motor blower circuit breakers are not tripped.

When necessary reset a tripped circuit breaker and operate the "reset" button at the side of the electrical cupboard adjacent to the Emergency Light Engine Switch - labelled fan reset.

Should the circuit fail to reset, the alarm will continue to operate and it will be necessary to move the Emergency light locomotive switch to the "Emergency" position to restore power on the locomotive.

The locomotives can only be operated as a light engine using the low speed notches (1 to 3) and full series only is available. Notching through resistances must be completed within sixty seconds with a maximum of 400 amperes per motor during notching.

When operating under above conditions the following motor currents should be observed.

150 amperes per motor continuous
230 amperes per motor for 25 minutes
270 amperes per motor for 15 minutes

If operation cannot be achieved without exceeding above amperages a relief locomotive must be obtained.

Regenerative braking is not available under these conditions.

WHEEL SLIP AND SLIDE CORRECTION

This function is entirely automatic. Wheel slip and slide is detected by generators provided on each axle. These speed and acceleration differences will be detected by the control system and correction will be made by reduction of current to the traction motor of the slipping wheel set only.

If wheel slip exists for more than two (2) seconds while operating in resistance notches the main resistance camshaft will automatically move backwards one notch.

When wheel slip occurs and is not immediately corrected, the driver is to take appropriate action by ensuring the rail is being sanded and reducing power to the traction motors to a level where the slip is corrected.

Should continuous wheel slip continue for a period of fifteen (15) seconds, the power circuit is automatically interrupted and a continuous wheel slip alarm will be given. To restore the power circuit, close the accelerating handle and press the fault reset button on the stand in front of the driver.

When the accelerating handle is moved to the "off" position and the alarm continues, this may indicate a tripped wheel slip circuit breaker and until the tripped circuit breaker is reset the wheel slip alarm will continue.

Check for defects on the locomotive, i.e. traction motor defects, wheels rotating etc. and if no defects are evident, move the Emergency light locomotive switch to emergency position and proceed as a light locomotive.

If the wheel slip alarm continues to operate under these conditions, place the locomotive in the first available siding and inform the maintenance staff.

Wheel Slide Protection in Regenerative Brake

If a wheel slide occurs in regenerative braking the braking current is reduced to approximately sixty percent of that value set by the position of the regenerative braking handle. After wheel slide is corrected the braking current is restored to the value at which the regenerative handle is set.

Demisters

Electric demisters are provided in each cab and supplied with 120 volt DC power through a Demister circuit breaker on the circuit breaker panel and controlled by a toggle switch on the driver's panel in each cab.

Hotplate

A hotplate is provided in each cab supplied with 240 Volt AC power and each controlled by a three position rotary switch. Each hotplate is fed through separate circuit breakers on the circuit breaker panel.

Headlights

Twin sealed beam headlights are provided at each end and fed from 240 volt AC power supply via headlight circuit breakers located on circuit breaker panel. Each pair of headlights is controlled by a three position switch located on the driver's console in each cab. Circuit breakers are also provided for the high and low beam circuits, located below circuit breaker panel.

Cab Refrigerator

Each cab is fitted with a refrigerator which is of simple design and uses air at high pressure for cooling under thermostatic control.

The cabinet is a top loading type and has a capacity of holding a water bottle and a supply of foodstuffs which may require to be kept cool.

It is the utmost importance that enginemen keep the refrigerator in a clean and hygenic condition at all times and do not place items of an odorous nature in them.

The air supply to the refrigerator passes through a two position isolating cock, which is open in the vertical position and closed in the horizontal osition. The cock is located on the rear panel of the cabinet.

The air demands for the operation of the refrigerators is high and to ensure sufficient air supply is available for other essential equipment on the locomotive, it is essential that before vacating the cab, Enginemen close off the air supply to the refrigerator by placing the two position isolating cock in the horizontal position and ensure that only one refrigerator is in use at any time.

AIR CONDITIONING

Air conditioning is provided in both locomotive cabs with 415 V AC Power supplied from the motor alternator (MA) set.

To avoid wear, the air conditioning unit in unoccupied cabs should be switched off.

Each air conditioning system consists of two separate units, the compressor condensor unit and evaporator unit. The compressor condensor units are mounted on the right hand wall of the locomotive at both ends and contain the circuit breakers for each unit. The evaporative unit contains the air circulating fan, cooling coil, heaters, thermostats and selector switch. A main air conditioning circuit breaker is located below the circuit breaker panel.

A test key switch is provided for maintenance purposes.

The selector switch is located above the Driver's seat just below roof level and is labelled:-

Heat High, Heat Low, Off, vent, Auto Cool.

Should the MA set fail the air conditioning will be inoperative.

Air nozzles are located below roof level towards the front of the cab and can be used to direct the flow of air, by both the Driver and observer.

Cab heating is best achieved by using the individual cab heaters in front of the Driver and Observer in conjunction with the heaters in the air conditioning unit.

The heaters in each cab are supplied with 240 volt A.C. Power through cab heater circuit breakers located on circuit breaker panel. Each heater is controlled through a High - Low switch on the respective consoles.

Vigilance Control Equipment

The purpose of the vigilance control equipment is to enable the crew of a locomotive, when running light or attached to a train, to prove their vigilance by means of a physical action, referred to as an acknowledgment, at short time intervals.

An audible or visible warning is given when the time interval has elapsed, indicating that an acknowledgment is required. Should an acknowledgment not be received after a further short interval of time, a brake application at or below service rate is initiated. To ensure that the locomotive or train is brought under full control, the brake application, thus commenced, cannot be released until the brake pipe pressure has been reduced to a very low value, thus necessitating an actual brake valve manipulation before a release can be made.

The vigilance control equipment fitted is the E.H. type with a solid state timing unit controlling a penalty application magnet valve which upon being de-energised will exhaust brake pipe pressure to atmosphere, i.e. the system is fail safe.

Operation of the E.H. Type Equipment

The electrical circuit for the operation of the vigilance control equipment passes through the reverser contacts and the acknowledgment buttons are inoperative while ever the reverser handle is in the centre (neutral) position and become operative immediately the reverser handle is moved to the forward or reverse position.

It is therefore most essential that before the reverser handle is moved to the centre (neutral) position, the vigilance control equipment is suppressed by fully applying the independent brake and brake cylinder pressure exceeds approximately 200 kPa.

Failure to ensure that sufficient brake cylinder pressure is present to suppress the vigilance control equipment, before moving the reverser handle to the centre (neutral) position, will result in the vigilance control continuing through its timing cycle and when the visible and audible warnings operate, they cannot be acknowledged and a penalty brake application will occur.

In the absence of an acknowledgment, after a further period of time, a third pair of contacts will close, causing a penalty brake application. When this occurs the bell is silenced and at the same time the acknowledgment buttons are rendered inoperative for one to three minutes.

The penalty brake application can be released after the one to three minutes time interval by depressing the acknowledgment button and operating the brake valve in the normal manner.

Isolating of Equipment

When isolating the apparatus it should be kept in mind that there are two stages of isolation for vigilance control equipment as follows:-

(a) Isolation of Emergency Application Valve Only

This condition eliminates a vigilance control brake application and still permits the flashing light - audible warning portion of the equipment to function. The associated isolating cock, located at the emergency Application valve inside the locomotive is to be closed.

(b) Isolation of the Complete Equipment

The isolating cock under vigilance equipment is to be closed.

The main vigilance control circuit breaker (VCB) must be opened.

Note: In every case where trouble is being experienced the procedure set out in (a) above must first be observed and only if a remedy is not effected by this means shall the procedure for (b) be applied.

Battery Switch

Before opening, close both Driver's brake valve isolating cocks. Vigilance control penalty valve when de-energised will dump brake pipe pressure.

This action is necessary to ensure the vigilance control is isolated by closure of the isolating cocks before the electrical circuit to the penalty magnet valve is interrupted by opening the battery switch.

(Blank Page)

Line drawing of No.1 end Bulkhead Pneumatics

ISOLATING COCKS

1. Horns (When closed, horns blow at operated end ONLY)
2. Pantograph
3. High Tension Interlock
4. High Tension Interlock and No.1 End Auxiliaries
5. Control Air
6. Compressor Governor
7. Vigilance Control Penalty Valve

ISOLATING COCKS

Below the Footplates

1. Two main reservoir pipe cocks at each end of the locomotive.

2. One brake pipe cock at each end of the locomotive.

3. Two sets of No.3 control and No.4 independent release cocks, at each end of the locomotive.

4. Two brake cylinder isolating cocks, left side.

5. Main reservoir isolating cock, left side.

In the Cab

1. Brake valve cut off valves, one on each brake pedestal.

2. Brake pipe emergency cock adjacent to the brake pedestal.

3. M.U. valves for isolating independent brake, one on each brake pedestal.

4. Refrigerator isolating cock, on side panel of refrigerator in each cab.

5. A small compartment is provided adjacent to the hotplate in which the following are located:

   (i) Horn
   (ii) Windscreen wipers and washers
   (iii) No. 2 end. An additional isolating cock is provided for the above equipment including the refrigerator.

In the Engine Room

Bulkhead behind No. 1 Cab.

1. Pantograph isolating cock No. 1 end.

2. Horn change-over cock.

3. High Tension door interlock.

4. An isolating cock situated below main reservoir which when closed isolates air supply to both high tension door interlock and auxiliaries No. 1 end.

5. Control air reservoir.

6. Compressor governor.

7. Vigilance control emergency application valve.

8. Control valve on brake equipment stand isolates locomotive automatic brake.

9. Dead locomotive device on brake equipment stand.

10. Two sets of sanding magnet valves, right side engine room wall located over each bogie.

11. Pantograph isolating cock, No. 2 end.

NOTE: The control valve isolating cock is located on the brake pipe and when closed, only isolates the automatic portion of the brake, i.e., the independent brake is operative with the isolating cock closed.

CIRCUIT BREAKERS AMD SWITCHES

The following circuit breakers are provided on the circuit breaker panel and protect the various circuits on the locomotive in accordance with the following:-

1. Remote supply (RSB) (sealed open) - Completes circuit from the source of supply on another locomotive in the case of flat batteries.
2. Spare
3. Vigilance Control (VCB) - vigilance control circuits.
4. Fault Breaker (FIB) - Fault, lights, bell and buzzer.
5. Supply Indicator Relay (SIB) - Operates blue light and bell to indicate loss of motor alternator (AC) supply. Alarm also operates in the event of this circuit breaker tripping.

6.	Regenerative brake control (RCB)	- Regenerative brake control circuits.
7.	Compressor Synchronise (CSB)	- Compressor synchronising circuit.
8.	Compressor Control (CCB)	- Compressor control circuits, both compressors.
9.	Pantograph Control (PCB)	- Pan up, Pan down and auxiliary relays set and trip coils. Motor alternator and compressor operation.
10.	Train control (TCB)	- motor alternator contactor for supply to motor alternator (MA) set, Compressor Control Circuit and control positive through the reverser contacts.
11.	Control positive (CPB)	- Master Controller supply through the control governor and regenerative brake control. Sanding magnet and reset buttons through reverser contacts.
12.	Main Control (MCCB)	- Traction control circuits.
13.	Spare.	
14.	Lighting Control 2 (LTS 2)	- No.2 end lights - cab, timetable, coupler, steps, number, marker, panel and toilet.
15.	Lighting Control 1 (LTS 1)	- No.1 end lights - cab, timetable, coupler, steps, number, marker and panel.
16.	Machine room lights (MRLB)	- machine room lights and high tension compartment lights.

17. Headlight (HLB)	- Headlight circuit.
18. Spare.	
19. Demister (DB)	- Demister circuit.
20. Hotplate (HPB1)	- Hotplate No.1 end.
21. " (HPB2)	- Hotplate No.2 end.
22. Heater (CHB1)	- Cab heater No.1 end.
23. " (CHB2)	- Cab heater No. 2 end.
24. Resistor Blower Motor(RBB11)	- Resistance blower fan motor circuits.
25. " " " (RBB12)	
26. " " " (RBB21)	
27. " " " (RBB22)	
28. Battery Charger (BACB)	- Battery charger, supply indicator circuit breaker (SIRB) and supply indicating relay.
29. Wheel slip/slide	
30. Blower motor control (BCB)	- Traction motor and resistance fan blowers control circuit.
31. Motor Alternator Control (MACB)	- Motor alternator output.
32. Pilot Motor Control (PMB)	- Main supply to the master controllers and camshaft pilot motors.
33. Traction Motor Blower(MBB1)	- Traction motor blower circuit.
34. Traction Motor Blower(MBB2)	- Traction motor blower circuit.
35. Battery Knife Switch (BS)	- Battery circuit.

36. Battery Ammeter (BA)

37. Supply Isolating Switch (SIS)- Controls the operation of the motor alternator and isolates the blue light and bell.

38. Main air conditioning supply - supply to both air conditioning units - below circuit breaker panel.

Electrical Cupboard — Machine compartment

	Function
Compressor Control Switch (CMS1)	No.1 Compressor Control
Compressor Control Switch (CMS2)	No.2 Compressor Control
Control circuit cut out switch (CCOS)	Power control circuits
Sequence test switch (SQ TEST SWITCH)	Testing control circuits.

The Control Cut Out Switch (CCOS) is a four position rotary switch with the positions: "ON", "OFF", "ON", "OFF".

In the "OFF" position the traction control circuits and motor alternator are isolated and the red power fault indicator light and amber failed resistor blower light will also be isolated.

The Sequence Test Switch (SQ. TEST SW.) is a four position rotary switch with the following positions: "Normal" and "Test". The switch is carried in the "Normal" position and is only placed in the "Test" position when a sequence check test is conducted without high tension supply at the workshop.

Compressor Control Switches CMS1 and CMS2 are the switches for No. 1 and No. 2 air compressor respectively.

PREPARATION

1. In the event of any equipment being found "cut out" unless labelled "Not to be used", or in the absence of a relevant entry in the Log Book, such equipment must be "Cut In".

2. If any authorised employee be at work on an electric locomotive at the time when the driver arrives to commence testing operations, and if such work is likely to affect the electrical or air equipment, the

Photo of Test and Cutout Switches

driver must not proceed with the testing operations on the locomotive concerned, or cause the locomotive to be moved, until the work has been completed and all danger discs removed from the departure end of the locomotives.

3. When an electric locomotive is stabled at a depot, the procedure outlined for stabling must be carried out by the stabling driver, unless instructed not to do so by the Operations Supervisor.

Preparation

Obtain Driver's Daily Report Sheet and Reverser handle. On arrival at locomotive peruse Log Book and commence preparation at No. 1 end.

Before joining the locomotive, ensure the brake cylinder and main reservoir isolating cocks are open.

No. 1 Cab

The following items are to be checked:-

1. Hand brake is applied.

2. Check the powering handle, regenerative handle are in "off" Reverse lever in "Isolate" and removed.

3. Drivers brake valve cut off in "OUT" MU2A valve in "Dead" position.

4. All switches on drivers and observers consoles not required are down and off.

Proceed to machine compartment

Check

(a) Circuit breaker panel left wall.

(b) Check ammeter for accuracy of zero.

(c) Close battery switch.

(d) Supply Indicating Switch (S.I.S.) "ON".

(e) All circuit breakers up and on except remote supply (RSB) which is sealed in the open position.

(f) Check spare globes supply in adjacent rack.

Check air cocks on bulkhead behind No. 1 cab.
Vigilance control sealed and all air cocks properly positioned.
Check fire extinguishers in machine compartment during preparation for charge and check seal.
Ensure the emergency light locomotive switch is located in the normal position and sealed.
Check electrical cupboard (through small door):-

(a) Control cut out switch (CCOS) is in "ON" position.

(b) Sequence test switch is in 'normal'.

(c) Compressor motor rotary switches (CM 1 and 2) are in "ON" position.

Warning. Enginemen are warned against opening the electrical cupboard as 415 volts electrical current is present. On no account are the doors to be opened while the pantograph is in the raised position or motor alternator operating.

Check sanding magnet valve isolating cocks open (R wall).
Check brake control valve and dead engine cocks correctly positioned - located under traction motor blower No.1 end.
Operate reverser handle in high tension door interlock.
Check high tension fuses are in position and spare fuses:-
1 x 20 ampere H.T. fuse (compressor).
1 x 10 ampere (no volt relay, polarity detector).
Check manual pantograph isolating switches are correctly located and sealed.
Ensure high tension door interlock properly locked.
Check motor alternator circuit breaker (ACB) is in "ON" position on right wall adjacent to traction motor blower No. 2 end.

No. 2 end

(a) Drivers brake valve cut out valve in "OUT". MU2A valve in "dead".

(b) All switches on drivers and observers consoles not required are turned "off".

(c) Insert reverser handle in "Isolate" position and move to "Off" position (centre).

(d) Press pantograph raise button.
If no main reservoir pressure is available the pantograph is raised by using a footpump (one each end of the locomotive).

In case of insufficient main reservoir air pressure the alarm bell will sound and the Red Power fault light (PFL) will shine because the high speed breaker will not close until 350 kPa brake pipe pressure is attained. The Blue Failed Alternator light (FAL) will also shine.

(e) Check line voltage is normal (1100-1500 V DC).
Note: If the line voltage is less than 110Ov the high tension machines will not operate.

Press Overload Reset Button (ORB) which should cause high speed breaker to close. Red Power Fault Light and Blue Failed Alternator Light to be extinguished also alarm bell to cease sounding.

When the motor alternator commences to run 415V 50HZ three phase power will be fed to the control and auxiliary circuits.

With main reservoir fully charged to 700-800 kPa, open brake valve cut off cock and MU2A valve and test brake as follows:-

1. The independent brake valve is to be in the 'application' position and the automatic brake valve in the 'release' position. The brake valve cut off valve set at 'IN' and MU valve in the 'lead or dead' position on the brake pedestal being tested.

2. Check the main reservoir, brake pipe and equalising reservoir pressures. The brake pipe and equalising reservoir pressure should be 500 kPa. The main reservoir pressure 700 to 800 kPa.

3. Place the independent brake valve in the 'release' position. The flashing light is to be acknowledged, whilst the brake test is being carried out.

4. Place the automatic brake valve in the minimum reduction position and note that a minimum reduction of 50 kPa takes place in the equalising reservoir and brake pipe pressures. The brake cylinder pressure should rise to between 70 and 105 kPa.

5. Release the engine brakes with the independent brake by depressing the handle in the 'release' position until a full release of brake cylinder pressure is obtained.

6. Place the auto brake valve in the 'service application' zone and reduce the equalising reservoir and brake pipe pressure by 75 kPa. Note that the regulating and relay valves function and the brake cylinder pressure increases.

7. Conduct a power and sand test. Place brake valve cut off valve in the 'out' position, check the brake piston travel is within required limits and sands are working correctly. Note that the brake pipe pressure has not seriously reduced or increased with the brake valve cut off valve set in the 'out' position.

8. Regenerative Brake Test. Place the reverser in the 'forward' position, and set brake valve cut off valve in the 'in' position. Move the regenerative handle to the braking position. Note that minimum brake cylinder pressure releases. When the brake cylinder pressure has released, reduce the brake pipe pressure to below 250 kPa. Note that the locomotive brakes re-apply. Move the regenerative handle to the 'off' position.

9. Place the automatic brake valve handle in the 'release' position. Note the brake pipe and equalising reservoir pressure is restored and the locomotive brakes release.

10. Fully apply the independent brake and check the brake cylinder pressure rises to 325 kPa. Move the accelerating handle to position 1. Note the loadmeter (ammeter) reading indicating that the pneumatic control switch has closed. Move the accelerating handle to the 'off' position.

11. Place the automatic brake valve in the emergency application position. Note that a heavy reduction occurs in the brake pipe and equalising reservoir pressure.

12. Move the automatic brake valve handle to the 'release' position and note that the flow meter functions correctly.

13. Place the independent brake valve handle in the 'release' position without depressing handle and note that the brake cylinder pressure releases.

14. Open emergency cock at base of pedestal and check that brake pipe is quickly and considerably reduced in pressure.

15. Maintaining feature check

Close emergency cock and fully recharge brake pipe.

Place auto brake valve handle in service zone and reduce brake pipe pressure by 70 kPa. Leave handle in this position.

Open emergency cock slightly to vent brake pipe and note that brake pipe pressure remains constant at the reduced level.

16. While the brake test is being conducted, the cutting in and out point of the governor is to be checked.

Lower and raise pantographs to ensure correct operation.
Set switches as required.
Isolate brake equipment.
Place reverser handle in "Isolate" and remove.

Alight from locomotive cab on driver's side.
Examine front of locomotive, checking all air cocks are closed and air hoses properly secured to dummy couplers. Check automatic coupling in good condition and operates correctly also jumper coupling in good condition and properly secured.

Pass down the side of the locomotive, examine brake shoes and rigging, springs etc. Check that brake cylinder isolating cocks are open, sands flow adequate and sandpipes set to rail, main reservoir isolating cock open, compressor oil level checked by lifting filler cap, main reservoirs, including battery box and condition of spare fuses.

Enter cab at No. 1 end, carry out instructions as previously detailed in No. 2 cab, lower and raise pantographs to ensure correct operation. Lower leading pantograph if it is not required.

Set required tail and number lights.

Check red flags, detonators, headlights, windscreen washers, wipers, marker gauge and interior lights.

At departure end, set up for operation and release hand brakes.

OPERATION PROCEDURE

Powering Control Handle

When working round a yard where precise control is required in small steps the first three notches are used. Notch 2 is a "hold" or "neutral" position and each time the handle is moved from this position the locomotive switchgear responds by changing one step. Placing the handle in notch 3 provides more current and tractive effort by cutting out one step of resistance. To take the next step it is necessary first to return to notch 2 and then go again to notch 3. Rapid repeated movement of the handle between 2 and 3 will provide a number of steps in quick succession if a high current is required. If the speed or current is too high moving the handle between 2 and 1 will increase the resistance one step for each movement provided the amber notching light is not extinguished.

When working with a train or light engine on the main line the controller is used mainly in the range between notch 4 and notch 5 where each position represents a fixed level of current and therefore tractive effort. In the minimum position of the 4 range the motor current is held at 340 amps while the switchgear steps through the resistances and the train gains speed gradually on relatively level track. In the maximum position stepping current is 900 amps which requires adhesion in excess of 28% to avoid wheel slip.

Trains on an easy grade will accelerate more quickly than the locomotive switchgear can step through the resistances so that the current stays low. If the handle is brought back to the position represented by this current it would make no difference to the acceleration. In fact it is good practice to do this to avoid the sudden increase in current when all resistance is cut out and the switchgear starts stepping through weak field notches.

The final notch of the controller beyond the 4 range is number 5 where the signal is given to the switchgear to make transition. If the train has been running for some time in 4 range after resistances have been cut out the motors will be operating in the weak field region and will need to be brought back to full field before making transition. This takes a little time and results in a delay before transition is started.

Driving Methods

Starting in a yard: Use notches 3 and 2 to start the locomotive and stretch the slack. Go back to notch 1 to reduce speed if the locomotive is rolling too easily. When the van is moving use notches 3 and 2 to accelerate the train sufficiently to clear the yard. Alternatively if the train is a heavy one requiring considerable current to start and is being held on the engine brake with the train brakes released the handle may be moved directly to the position in 4 which will provide almost 400 amps to hold the train. The independent brake is released as current builds up and the controller handle is advanced in small steps till the train starts. The handle may be left there as the train accelerates until speed is sufficient to move through the rising grade of the yard when the handle is moved nearer to 4 minimum to reduce the tractive current and hold a steady speed.

Starting on level or easy grade: Release the automatic brake and as the train brakes ease off move to notch 4 minimum to hold the train. Advance the controller handle in small steps to build up current sufficiently to move the locomotive and hold at this position until the train is stretched and the van is moving. Then advance the handle to achieve about 800 amps and provide rapid acceleration with quick stepping through the resistance.

When the resistance notch light goes out at about 12 km/h move the handle directly to notch 5 for transition and then return it immediately to the previous position to continue acceleration at about 800 amps. At about 27 km/h the resistance light will go out again for running in series-parallel. If speed must not exceed 60 km/h and the grades are still easy series-parallel is suitable for all but the heaviest trains.

If higher speed is required, as soon as the resistance light goes out, move the handle to notch 5 for transition and back again to the 800 amp position to accelerate to parallel.

Lifting a heavy train on a steep gradient: Care must be taken to allow time for brakes to release fully before attempting to accelerate the train. This is no problem if the train is being held with the independent brake only, but if the automatic brake is applied the brake handle should be moved to release before applying power.

As the brakes start to release move the power handle to step up to about 600 or 700 amps to hold the train as the brakes come off. When the locomotive starts to move forward allow it to travel one or two engine lengths to check the brakes are free before advancing the controller. If the engine does not move advance the controller in small steps of about one millimetre until the train moves and leave it in this position for an engine length or so. Then advance the controller towards 900 amps until wheel slip is experienced. If slips occur within 2 or 3 seconds of each other the handle should be brought back in small steps, only 1 or 2 millimetres each, to prevent frequent slipping. If slipping is only one or two occurrences every half minute or so the handle may be advanced slightly to seek the maximum acceleration available.

Extinguishing the resistance light is the signal for moving to notch 5 for transition and then returning the handle to maintain the same stepping current as previously.

The tractive effort available from 750 amps is sufficient to accelerate a train on most grades and 800 amps will provide good acceleration everywhere. This current provides the same tractive effort as 950 amps with a 46 Class locomotive.

Starting a light train: As mentioned earlier the switchgear controlling the resistance, steps relatively slowly and will not keep pace with the acceleration of a light train. The result being that with the controller handle in the right position for stepping at 600 amps only 400 amps is being achieved. The temptation to move the handle round further for quicker acceleration achieves nothing until resistance is cut out when suddenly it steps quickly through weak field notches to yield perhaps 800 amps and a surge of acceleration.

It would be better to resist the temptation and to move the handle back to match the 400 amps available, acceleration will be no slower and there will be no surge into weak field. Better still is to place the handle fully in notch 5 so that transition is made immediately resistance is cut out and no attempt is made to take unwanted weak field steps. Transition is made in the shortest possible time and although some shock is felt on the locomotive it is over too quickly to have a significant effect along the train.

Starting a train with bunched slack: As in lifting a train from a yard start off using notches 2, 3, 2, 1 etc., to stretch the slack and when the van is moving take notch 4 and then accelerate the train as already described.

Running at Speed: As mentioned earlier series-parallel combination is suitable for speeds below 60 km/h and for light trains on easy grades can even be used up to 80 km/h. The controller in the wide 4 range will hold the current around the nominal value for each position by taking or releasing weak field steps and the response of the locomotive when moving through the notch 4 range is very similar to that of a diesel working between notch 4 and notch 8. When working through undulating country the speed must be regulated by appropriate movement of the controller handle. If the speed rises too high in minimum 4 it is necessary to shut off and coast.

Series-parallel is useless for general trains at speeds below 40 km/h and can only be used for heavy trains on rising grades for speeds about 35 km, so that where the speed range is 20 to 40 km/h series is the appropriate combination.

"Picking up" at speed: When it is time to re-apply power after coasting down an incline or allowing speed to fall for a speed restriction it must be remembered that resistance steps are cut out slowly and it can take all of ten seconds after moving the controller handle before effective power is available. When running at 100 km/h the handle should be moved to pick up the train 300 metres before the required location to allow for this delay. The handle should be moved directly to notch 5 and left there while the resistance light has gone out and come on again twice as the motors have switched through series and series-parallel combinations. While finally stepping through parallel resistances the handle should be brought back to the suitable position for the anticipated current in weak field.

If the speed is low or power has been shut off to approach a low speed limit below 35 km/h, transition beyond series will not be required and the delay in providing power will be reduced so that 2 or 3 seconds before power is needed the handle is moved directly to the current setting in the 4 range that will be suitable to run the train in series.

For speeds up to 70 km/h on easy grades allow 5 to 7 seconds delay, or about 100 metres before the point where power is wanted, to place the handle in notch 5 and then bring it back to the right current position as soon as the resistance light has come on again after transition to series-parallel.

TRANSITION

Transition from Series to Series-Parallel

If a further increase in speed is required providing the resistance notch light is not illuminated the "Powering Handle" is momentarily placed in Notch 5 (Transition) and returned to Notch 4 causing the transition to Series-Parallel combination, automatic notching occurs through to Series-Parallel Weak Field. Using the "Powering Handle" in this zone, accelerating current can be varied from 340 amperes to 900 amperes thus enabling the driver to control his accelerating rate. While operating in Notch 4 if a reduction in speed is required the "Powering Handle" can be moved back, thereby reducing the current to the traction motors.

Transition from Series-Parallel to Parallel

If a further increase in speed is required whilst operating in Series-Parallel the "Powering Handle" is momentarily placed in Notch 5 (Transition) and returned to Notch 4 causing transition to the Parallel combination (providing resistance notch light is extinguished). Once again automatic notching will occur through to Weak Field and by varying the "Powering Handle" position, acceleration current can be controlled between 340 amperes to 900 amperes.

While operating in Notch 4 if a reduction in speed is required, the "Powering Handle" can be moved back thereby reducing the current to the traction motors.

The following amperages must not be exceeded:-

1100 amps when lifting train for 10 seconds
900 amps for five minutes
730 amps for one hour
690 amps continuous

Speed Reduction

If a speed reduction is required, return Powering Handle to the "OFF" position until desired reduction in

speed is achieved then return the Powering Handle to the appropriate position e.g.,

Note: There is no backward transition as on a 46 class locomotive.

If a speed reduction is required from series-parallel or parallel combinations the Powering Handle is returned to "OFF" position and then placed in Position 4 where the locomotive will keep notching automatically to maximum series weak field position. If the obtainable speed in this combination is not sufficient, series-parallel combination is selected by moving the Powering Handle to Position 5 momentarily from "OFF" position (providing the Resistance Notch light is extinguished) the control circuit will be established and transition effected. This manoeuvre is repeated if a higher combination to Parallel is required.

Shunting and Low Speed Control in Series Combination

From the "OFF" position advance the Powering Handle to Notch 3 which moves the resistance camshaft one step forward. The handle is operated between Notch 2 (Hold) and Notch 3 (Notch up) until the desired speed is obtained when the handle is maintained in Notch 2 (Hold).

If a reduction in speed is required the Powering handle is returned to Notch 1 (Notch down) and back to Notch 2 (Hold) which moves the resistance camshaft one step backward.

This is repeated until the desired reduction in speed is achieved.

Operating through Water

Under no circumstances should the locomotive be operated through water that is deeper than 100 millimetres above rail level and speed must not exceed 3 kilometres per hour.

Operation over points and crossovers

When operating the locomotive at speeds in excess of 40 km/h reduce the motoring current by returning the Powering Handle to the minimum current position in Notch 4 seven seconds before the locomotive reaches a railroad crossing or points.

When operating in regenerative braking reduce the regenerative handle to minimum position as above.

This action is required to minimise brush bounce and thereby reduces fusion damage between the carbon brushes and commutators of the traction motors.

Special Driving Conditions:

Low Overhead Volts. The problem of low overhead voltage will be eased a little when the Electrical Branch complete their modifications on the West but it will not be eliminated so that the following notes will apply in the future as well as now.

The problem arises because too many trains are using the supply from one substation; the current demand is too high. The voltage falls, trains lose speed and time, and the temptation is to use weak field to regain speed. However, under these circumstances the result is even slower running. The explanation comes from an examination of what is happening in the locomotive.

It must be understood that the train, be it heavy or light, is on a rising grade and needs so much tractive effort to proceed. The motor gives its maximum tractive effort for a given current in full field but in weak field to give the same tractive effort the armature current must be increased by the same amount that the field current is weakened. As the current drawn by the locomotive increases the voltage falls even further and the loss in voltage is greater than the gain in speed.

Under these circumstances it is necessary for all trains in the section to draw the minimum current they need so that the voltage drop is as small as possible. Whenever the overhead voltage falls below 1300 volts all drivers, whether on interurban, 46 Class or 85 Class locomotives should run in full field. On the 85 Class this is achieved by going to minimum 4 position.

Empty Coal trains. The number of locomotives required to haul a loaded coal train are far in excess of those needed for the return empty journey but the units must also be returned for the next trip. It is harmful to traction motor commutators if they run long distances without some current flowing through the brushes so that trailing units must not be cut out to reduce the surplus of power. However, power can also be reduced by not taking transition and this is the easiest way.

On relatively level sections such as Parramatta to Emu Plains, the use of series only with weak field stages will run the table and leave very few occasions when a reduction to full field will be required. Sometimes the speed will drop towards 40 km/h over crests but the time lost will be slight and the train will be kept stretched all the way. Beyond Emu Plains series-parallel will be sufficient, most of the time in maximum weak field. Sometimes to keep within a speed limit the controller may be moved towards 4 minimum to reduce the number of weak field steps.

Double Heading with 46 Class. As mentioned earlier the 46 Class unit draws far more current for the same tractive effort than an 85 Class unit, for the same reason it draws more current when running at the same speed. This is of little consequence unless the grade is severe. However, on heavy grades there is a risk that not only will the 46 Class unit be overloaded but also if a number of locomotives are involved the abnormally high current in the 46 Units will overload the supply system.

The driving technique required is to set the 85 Class controller so that the current drawn on the 85 Class is the same as on the 46 Class. This ensures that the total load is shared evenly between the units and generally means that the 85 Class will be running with one step of weak field in circuit.

Regeneration: The regenerative brake is very powerful and should be treated with respect for this reason. It is also quick to respond to controller handle movement and to changes in the overhead voltage. When two units are coupled the heavy demand placed on the overhead to carry away the braking current is frequently more than the overhead wires can conduct. This leads to an overvoltage trip and failure of the regen brake.

Regenerative brake should be handled in the following manner:-

Series braking is suitable if the train speed is not to go higher than 60 km/h and until the changes mentioned above are completed is the more reliable mode to use. Select regeneration when the train speed is 45 km/h or slower (but not below 25 km/h) and leave the brake handle at the minimum brake position while the brake circuit is set up and the train bunches gently on the locomotive.

After the slack has bunched move the handle to the approximate position required depending on the load and grade. This position provides a constant brake effort regardless of the speed and thus needs adjustment as the grade changes in the same manner as the power handle does to alter weak field steps when running through undulating country.

When moving the brake handle to control the degree of braking it is more useful to watch the line volts meter than the armature current meter. The speedometer shows if more or less braking is required and because of the fine response of the controls very small movements of the handle make a considerable change to the current and voltage values. The handle should be adjusted in very small movements of only one or two millimetres when the desired running speed has been reached. When the line voltage reads over 1900 volts a watchful eye should be kept on the voltmeter and fine adjustment made of the controller handle to check that it does not rise above 2,000 volts.

It is possible for the current to rise towards 900 amps at the upper end of the speed range. This may be tolerated for only a few minutes at a time and current over 850 amps should be avoided.

If the speed range is generally above 50 km/h enter regenerative brake at about 60 km/h, pause in minimum to bunch slack and then advance the handle to the required position - generally the same position as is used for series braking - to match the load and grade.
Be warned to watch the voltmeter carefully as even a single unit locomotive could lead to over-voltage.

If wheel slide is experienced it will usually be detected and corrected automatically and quite quickly. However, in bad rail conditions it may be necessary to reduce the regenerative brake manually to correct a bad slide that is beyond the automatic control. There is no need to go out of brake but it should be left at minimum

for 2 or 3 seconds before restoring the handle a little way short of the previous position and then gradually increasing the brake to the required level.

Regenerative Control Handle

This handle like the power handle in 4 range is arranged to provide a steady level of response for each position. The minimum braking effort is kept low to reduce as far as possible the shock to the train as regenerative brake is set up and the maximum brake looks for an adhesion level that may well be higher than track conditions allow. Automatic slide control is available and frequently sufficient. Automatic voltage control is not provided however, so that care must be taken to ensure that the overhead line voltage does not rise above 2,000 volts.

If the speed is below 45 km/h when entering regenerative brake the motors will be connected in series and the operating range will be between 25 and 60 km/h with the brake being most effective between 35 and 40 km/h. For series-parallel regeneration the speed must be over 55 km/h when entering regeneration and the operating range will be 45 to 90 km/h with the most effective brake being available between 52 and 57 km/h.

REGENERATIVE BRAKE CIRCUIT

There are two stages of regenerative braking. The six (6) traction motor armatures are either connected in series or in series-parallel with 3 motors in series in each group. The six traction motor fields are separated from the high tension circuit and connected in series in both stages. The fields are supplied by means of an exciter rectifier and step down transfer from the 415 V auxiliary supply from the motor alternator (MA) set.

The amount of regenerative braking is controlled by variation of the traction motor field current.

Regeneration-Brake Control

Regenerative braking can only be obtained if the reverser handle is in the forward position.

The braking range is set to provide maximum to minimum braking provided the current and weak field ratio limits are not exceeded to cause unstable traction motor operation.

The maximum armature current limit of 900 amperes in braking is gradually decreased to 730 amperes automatically during a time interval of ten (10) minutes to prevent over-heating of the traction motors. From the above it will be noted that the braking effort may be gradually reduced after the initial application even though the regenerative braking handle is in a fixed position.

The current limit is reset to 900 amperes by moving the braking handle to "OFF" position and then returning it to the braking zone.

When the speed is more than 55 km/h braking occurs within the series-parallel combination automatically. When the speed is more than 20 km/h and between 55 km/h series combination is selected automatically. In the event of the braking combination needing to be changed the regenerative braking handle is to be returned to the OFF position and braking will then be established upon the opening of the regenerative braking handle in the correct combination.

A voltage polarity detector (VPD) is provided to detect that the voltage of the armature circuit is slightly higher than the overhead supply voltage before closing the line switches to commence braking.

LOSS OF OVERHEAD POWER

Loss of overhead power to a locomotive can arise from two possible causes, namely:-

(i) A fault within the electrical equipment of the electric rolling stock.

(ii) Loss of supply to the overhead wiring caused by an overhead wiring fault or by loss of supply to a sub-station.

Electric Locomotives - Single Units

(i) As soon as possible after the initial loss of power, return the Powering Handle to the "off" position and if using regenerative brake, the regenerative handle to the "off" position. Avoid stopping with any portion of the train on a bridge, viaduct, catch-points, crossing or in a tunnel, under an air gap, or any position likely to obstruct trains on another line.

(ii) If supply is not available two minutes after the initial loss of power, the driver should switch off motor generators and compressors, lower pantographs, observe that they are lowered.

(iii) Four minutes after the initial loss of power the driver should raise one pantograph and arrange to have it carefully observed when it makes contact with the overhead wire.

(iv) If a flash occurs and power goes off immediately, as indicated by the line voltmeter in the driver's cabin. it is probable that there is a fault on the locomotive. If such is the case, the pantograph should be lowered and arrangements made for a relief locomotive to be obtained.

(v) If power is restored and remains restored, proceed.

(vi) If there is no flash at the pantograph and power is not restored the pantograph should be lowered.

(vii) The pantograph should be raised after a further period of two minutes for a similar test. If there is no indication of return of power it should be lowered again. The observer should then be sent to communicate with the nearest signal-box.

(viii) The driver should act on instructions received from the Signalman and, unless he has definite knowledge that his locomotive is defective, he should raise a pantograph every five minutes to test for the return of power and lower it if power has not been restored.

(ix) He should make arrangements for the securing and protection of the train as required in accordance with the regulations.

Electric Locomotives - Multiple Unit

In the case of electric locomotives in multiple unit consists, the driver should carry out the instructions detailed above for single unit electric locomotives except that operation (iii) should be applied to one pantograph

of the leading locomotive, and operation (vii) to one pantograph of the trailing locomotive.

Protection of Train

The train crew must make arrangements for protection of the train where required in accordance with the provisions of Rule No.243, 244 or 245 where applicable.

Loss of Overhead Power on Heavy Gradients

If overhead power is lost when a train is ascending or descending a heavy gradient an immediate application of the automatic air brake is to be made to stop the train which is then to be secured by the application of sufficient hand brakes to hold it stationary on the grade and the automatic brake released. This instruction must be observed at all times, as it is essential that the train be brought to a stand before main reservoir pressure has been depleted. When power is restored, full main reservoir pressure must be obtained and brake pipe recharged before the hand brakes are released.

PANTOGRAPHS

Most wear on the overhead wire is caused by passage of current to the pantograph strips rather than by friction between wire and strips. It is therefore desirable at all times when hauling a train to operate with both pantographs raised. The current density at the pantograph strips is thereby kept as low as possible and the rate of wear on the overhead wire kept as low as possible.

The number of pantographs to be raised is summarised below:-

Location Between places stated	Number of pantographs to be raised on each locomotive			
	Metropol-itan Area generally	Rhodes and Gosford Liverpool and Glenlee	Nepean River Bridge and Katoomba	Katoomba and Lithgow
Light Engines				
one, two or three locomotives (d)	1	1	1	1
Hauling Trains				
single locomotives				
any speed	2	2	2	2
Two units coupled				
below 90 km/h	1	2	2	2
above 90 km/h	1	1	(a)	(a)
Three units coupled				
any speed(c)	1	1	2	1(b)

NOTES: The rear pantograph should normally be raised where only one is permitted.

(a) Speed not to exceed 90 km/h on this section.

(b) Two pantographs should be raised on each locomotive between Lithgow and Bell only in the up direction.

(c) Locomotives must not be operated in parallel.

(d) Light locomotives may run at normal track speed.

(e) To comply with these instructions, it will be necessary for drivers of coupled electric locomotives to raise and lower the pantographs, if necessary, when passing the following points:-

West: Penrith - Katoomba - Bell (up only)

North: Rhodes

South: Liverpool

North Shore: Hornsby

(f) Pantographs may be raised or lowered with the locomotive(s) in motion, providing the powering handle is first moved to the off position. It is important to ensure at all times that pantographs are in the fully raised or lowered position, to avoid damage to overhead equipment.

MULTIPLE UNIT OPERATION

These locomotives can only operate with other 85 Class locomotives in a multiple unit consist. At all other times, should it be necessary to operate with locomotives of different types then both units must be manned.

When operating with multiple units, the normal practice is for all locomotives to have the jumper couplings inserted between them, thus providing for control of all locomotives from the leading driver's cabin.

The locomotives are to be prepared as described in preparation duties.

Each locomotive is equipped with a 42 pin jumper coupling at each end and suitable air hose couplings. When the locomotives are coupled for multiple unit operation, one jumper coupling is to be connected between the locomotives. The brake pipe and main reservoir, No. 3 control and No. 4 independent release air hoses are to be coupled and all relative air hose cocks opened.

Control and Brake Valve Handles

When operating with units in multiple unit consists, reverser handle, automatic brake valve handle, and the independent brake valve handle should be in position on the appropriate equipment in the leading driver's cabin.

In all other cabs in the locomotive consist the reverser must be removed from the control stands in "Isolate" position. Brake equipment cut out in accordance with instructions.

CHANGING OPERATING STATIONS

The following procedure is to be adopted when changing operating stations.

1. Fully apply the independent brake and place M.U. valve in the trail position. Move the independent brake valve handle to the release position and remove the handle.

2. Reduce the brake pipe pressure by placing the automatic brake valve in the handle out position reducing the equalising reservoir and brake pipe pressures to 70 kPa, move the brake valve cut off valve to "OUT" position.

3. The accelerating and regenerative brake handles are to be in the "off" position and the reverser handle placed in the isolate position and removed. The motor alternator will stop when the reverser handle is moved to the "Isolate" position.

4. The Powering switch is to be turned "off".

5. The driver is to remain at the control stand being vacated with the automatic brake valve in the "handle out" position.

6. The observer is to proceed to the stand being cut in, fully apply the hand brake, insert the independent brake valve handle, place the M.U. valve in the "lead or dead" position, release and fully apply the brakes.

7. The driver is to observe that the brakes have released and applied and not less than 300 kPa is indicated on the brake cylinder gauge, and remove the automatic brake valve handle.

8. Proceed to the control stand being cut in with the automatic brake valve and reverser handle, insert the automatic brake valve handle and reverser handle then place the brake valve cut off valve at the "in" position.

9. Move the reverser handle from the isolate position, turn on the Powering switch and press the fault reset button to restart the motor alternator. The failed alternator blue light and bell will operate for approximately thirty (30) seconds due to it being necessary for the alternator output to exceed a predetermined voltage before the alarm ceases.

Note: When the reverser handle is moved to the isolate position, the high speed circuit breaker trips and opens the line switches, which stops the alternator.

10. The brakes are to be tested in the normal manner and the observer is to release the hand brake under the driver's supervision.

AMALGAMATION AND DIVISION OF UNITS

Multiple Unit Operation Instructions and Amalgamation

85 class electric locomotives may be operated in multiple unit consists of two, three and four with their own type. When operating in combination with other units all locomotive types must be manned.

Coupling the locomotive

The automatic coupler head is to be placed in position laterally by the observer, guard or shunter, to ensure that it is lined up correctly for the connection to be made. This is particularly necessary when the operation is being carried out on a curve in order to avoid damage to the couplers when being connected.

To obviate the possibility of damage being caused through couplers not being in the correct position, the driver must bring the locomotive to a stand 1 metre from the vehicle to which it is to be coupled, so that the observer, guard or shunter may satisfy himself that the coupler head is correctly aligned.

This procedure is essential and must be strictly adhered to when coupling 85 class locomotives to vehicles or locomotives fitted with automatic couplers and buffers, for example the buffers may foul the control pipe fittings on 85 class locomotives.

Coupling of Units for Multiple Unit Operation

1. When the unit is prepared, place in position and secure with the independent brake in the application position, hand brake to be applied.

2. (a) Note the brake pipe and brake cylinder pressure.

   (b) Powering and Regenerative brake handles to be in the 'off' position.

   (c) Move the reverser handle to the 'isolate' position.

3. On trailing unit:-

   (a) Move the trailing unit onto-the leading unit and engage the automatic couplings. Test pull to ensure that they are properly coupled. Secure

the automatic coupling locking catch in position.

(b) Reduce the brake pipe pressure to 350 kPa and place brake valve cut off valve in the 'out' position.

(c) Reduce the brake cylinder pressure to 150 kPa.

(d) Remove the automatic brake valve-handle in the 'Handle out' position. Place the M.U. valve in the 'trail' position and remove the independent brake valve handle in the release position.

(e) (i) Powering and Regenerative brake handles to be in the 'off' position.

(ii) Place the reverser handle in the 'isolate' position and remove.

4. Couple the brake pipe, main reservoir, No. 3 control and No. 4 Independent release air hoses and open the associated cocks.

5. Note that the brake pipe and brake cylinder pressures build up on the air gauges to the same setting as on the leading unit.

6. Supervise the insertion of the jumper coupling.

7. The reverser and brake, valve handles are to be suitably located in the No.1 end driver's cab.

8. On leading unit:-

(a) Test the operation of the pantographs.

(b) A check is to be made between the units to ensure that there is no leakage on the air hose connections.

(c) Release the hand brake.

(d) Move the reverser handle from the isolate position, operate powering switch to 'on', press the fault reset button to restart the motor alternator.

(e) Proceed with normal operation.

Coupling for Multiple Unit Working - Observer's Duties

1. Upon preparing to couple the units, open and centre the automatic couplers to ensure they engage when brought together.

2. When the automatic couplers are brought together, wait until the driver test pulls the couplings to make sure that they are properly engaged. Then secure the automatic coupling locking latch in position.

3. Couple up the brake pipe, main reservoir and one set of independent brake air hoses.

4. When driver signals, open the air hose cocks between the units.

5. Ensure the jumper head is inserted correctly.

NOTE: In all cases where time is allowed for the turning of units and piloting locomotives to whistling out point, such duties must be performed by the observer.

MULTIPLE UNIT OPERATION - DIVISION OF UNITS

When units are being divided in multiple unit working either in depots or at stations enroute to suit traffic requirements, the following procedure is to be adopted:

1. When the locomotives have been brought to a stand, they are to be secured with a full application of the independent brake and hand brakes are to be applied.

2. The observer is to remove the jumper coupling and secure it in the dummy receptacle.
Close the brake pipe, main reservoir and independent brake pipe air hose cocks and uncouple the air hoses.

3. On the Trailing Unit:-
Place the automatic and independent brake valve handles in position. Move the M.U. valve to the 'lead or dead' position and fully apply the independent brake. Place the brake valve cut off valve at the "in" position and move the automatic brake valve handle to the release position.

4. The observer will then ease the Driver up, disengage the automatic couplers and attach air hoses to the dummy couplers.

5. Two wooden chocks are to be located on each side of the No. 2 wheel of the stationary locomotive.

6. On leading locomotive, proceed with normal operation.

STABLING

When the locomotive has been brought to a stand at the point of stabling the following duties should be carried out.

1. Fully apply the independent brake.

2. Reduce the brake pipe pressure by placing the automatic brake valve handle in "handle out" position, place the brake valve cut off valve in the "OUT" position.

3. The powering handle is to be in the 'off' position, the Regenerative handle in the 'off' position, the reverser handle placed in the 'Isolate' position and removed.

4. Press Pan down buttons to lower pantographs.

5. When leaving locomotive, open battery switch, close all windows and doors.

6. Hand brake to be applied.
   Enter all defects in the log book.

7. Chocks to be placed each side of No. 2 wheel.

POSITIONING OF CONTROLS FOR HAULAGE OF DEAD LOCOMOTIVES

Should a locomotive fail and be left at a station, the qualified Driver, prior to leaving the unit must secure the locomotive by means of the hand brake and carry out normal stabling duties and leave the unit in order vide instructions relating to the haulage of the unit.

An electric locomotive of any type when required to be hauled dead must not be attached to a train unless a qualified Mechanical and Electrical Equipment Branch Technical Officer or Technician has certified to its fitness to be hauled. Where possible a Driver required to haul a 'dead' locomotive, should contact the District Manager, Locomotives and Rolling Stock or other Technical Officer nominated, for clearance to do so.

The following procedure is to be adopted on the 'dead' locomotive:-

1. Under normal operating conditions when the No. 3 control and No. 4 independent release air hoses can be satisfactorily coupled for multiple unit air brake operation.

   (a) Air brake equipment is to be set up for normal multiple unit operation.

   (b) Powering handle in the 'off' position, regenerative handle in the 'Off' position, and reverser handle removed in "Isolate" position.

   (c) All switches to be turned "OFF" on the control stand, circuit breakers on the control panel to be left "ON". Battery switch open.

   (d) Vigilance control emergency cock to be closed.

   (e) Main reservoir, brake pipe, No. 3 control and No. 4 independent release air hoses are to be coupled between the locomotives and associated air cocks opened.

   (f) The brakes must be operative on the dead locomotive.

2. When the No. 3 control and No. 4 independent release air hoses cannot be coupled between locomotives fitted with 26L brake equipment.

   A competent employee, qualified for 26L brake operations must travel on the 'dead' locomotive for the purpose of releasing the locomotive brakes, by depressing the independent brake valve handle when the brake pipe pressure is restored upon each release of the automatic brake from the leading locomotive.

   (a) Driver's brake valve cut off valves are to be in the 'out' position.

   (b) Automatic brake valve handle is to be placed in the 'handle out' position and removed.

   (c) At the brake pedestal being operated on the 'dead' locomotive, the independent brake valve handle is to be carried in the release position and the MU valve placed in the 'lead or dead' position.

(Blank Page)

Photo of High Tension Compartment Fuse Panel

(d) Powering handle in off position, regenerative handle in the 'Off' position and reverser handle removed in "Isolate" position.

(e) Main reservoir and brake pipe air hoses are to be coupled between the locomotives and associated air cocks opened.

(f) Brakes are to be applied and released from the leading locomotive and their correct operation checked on the 'dead' locomotive before departure.

NOTE: When a main reservoir air supply is not available from the assisting locomotive the dead locomotive device is to be placed in the open position to charge the main reservoir on the 'dead' locomotive.

Hauling of Dead Locomotives from a Depot

When a locomotive is being hauled 'dead' from a depot it will be the responsibility of Depot Officers making these arrangements to ensure that the 'dead' locomotive is correctly set up, the air brake equipment is properly positioned and connected for dead haulage and that the brakes apply and release satisfactorily when remotely controlled from the hauling locomotive.

It is not necessary for the Driver of the train by which the dead locomotive is hauled between depots to be qualified for it, but, if he is qualified for the type of brake equipment with which it is fitted, he will be expected to effectively deal with any brake troubles occurring enroute.

FUSES

The following fuses are provided in the high tension compartment.

(a) A group of three 10 amp fuses which are:-

(i) Polarity detector positive and negative fuses. These fuses protect the polarity detector circuits which ensure a slightly higher voltage is present in the traction motor armature than in the overhead before the line switches close and regenerative brake becomes effective. Should a fuse fail, regenerative brake becomes inoperative and if the

regenerative handle is open, the red fault light will shine and alarm bell sound.
To correct the fault, press the reset button and if this fails to have the desired effect, test and renew the 10 amp fuse.

(ii) No volt relay fuse.
This fuse protects the no volt relay circuit and in the event of it failing, overhead supply is lost and the line switches will open, causing the red fault light to shine and alarm bell to sound.
Close the accelerating or regenerative brake handles and press the fault reset button. Should this action fail to correct the defect, test and if necessary renew the 10 amp fuse.

(b) Two compressor 20 amp fuses, one for each compressor. Should either of these fuses fail, the compressor will stop and it will be necessary to test and renew the defective fuse.

(c) One spare 20 amp and one spare 10 amp fuse are located in the high tension compartment.

DRIVERS, SPARE AND EMERGENCY EQUIPMENT

The following equipment shall be carried on 85 class electric locomotives:-

Drivers Equipment

1 tail disc.
2 cases of 12 detonators. One in each cabin.
2 red flags (in flag cases). one in each cabin.

Tools

1 spanner, hose M.R. and B.P.
1 pin punch
1 chisel
1 hammer

Spare and Emergency Equipment

1 screw wrench
1 brake pipe hose - 25 millimetres
1 brake pipe hose - 32 millimetres
1 rope - 1220 millimetres
Spare fuses 1 x Compressor 20 ampere
1 x no volt relay 10 ampere

2 fire extinguishers

FAULTS, FAILURES AMD THEIR REMEDY

The following is a complete coverage of the defects that may manifest themselves due to the malfunction or complete breakdown of equipment and the appropriate action required of the driver.

In the event of a defect developing before attempting to rectify the fault, ensure all circuit breakers are on and check which fault light is shining.

1. Discharged Battery

In this case the auxiliary machines cannot be started when battery voltage is less than 70 volts DC until coupled to another 85 class locomotive.

Remedy

(a) Couple another locomotive to the unit with flat batteries.

(b) Connect the jumper coupling between the units.

(c) Check that motor alternator is operating on normal locomotive.

(d) Break seals and place "Remote supply" circuit breakers (RSB) on both locomotives in "ON" position.

(e) Raise pantographs on disabled unit and start the motor alternator and compressors.

(f) Place the remote supply breakers (RSB) in the "OFF" position on both locomotives once motor alternator commences operation.

(g) Enter defect in log book.

Caution

Be sure remote supply breakers (RSB) are turned "off" before coupling or uncoupling locomotives otherwise severe burning of the jumper pins will occur.

2. Lights will not go on when motor alternator is not running

The following items are to be checked:-

(a) Battery isolating switch is closed.

(b) All miniature circuit breakers (MCB) are "ON".

(c) Renew battery positive or negative fuses if required located in fuse box adjacent to storage batteries.

3. Pantograph will not go up

The following items are to be checked:-

(a) Reverser handle is not in "Isolate".

(b) High tension compartment door is closed and correctly locked.

(c) Pantograph control circuit breaker is "ON".

(d) Air supply isolating cocks on bulkhead in machine compartment correctly positioned.

4. Line Voltmeters do not register

The following items are to be checked:-

(a) Pantograph is up.

(b) Pantograph rotary isolating switches in high tension compartment correctly located.

(c) If the line voltmeter is not registering a reading and power is available (indicated by motor ammeter registering a reading) the locomotive may be operated normally. A suitable entry is to be recorded in the log book.

5. Both compressors fail or will not start

The train is to be brought to a stand immediately and secured by the application of sufficient hand brakes to hold it stationary and protected in accordance with regulations. The following items are to be checked:-

(a) Line voltmeter is registering overhead supply is available.

(b) Compressor control circuit breaker.

(c) Compressor governor synchronising circuit breaker (CMGB).

(d) Train control circuit breaker (TCB).

(e) Compressor governor isolating cock open and contact points closed.

(f) Compressor switches CMS1, CMS 2 correctly positioned.

(g) Test and renew compressor fuses if required.

Note: When operating in multiple unit consists the governor synchronising circuit breaker (GSCB) should also be checked.

6. One Compressor only fails or will not start

Continue with normal operation if sufficient air pressure available and at earliest convenient opportunity:-

(a) Check compressor motor switches (CMS1, CMS2) are turned "ON" in electrical cabinet.

(b) Renew 20 ampere compressor fuse.

7. Failure of motor alternator

The following items are lost:-

(a) One source of supply for low tension circuit.

(b) Battery charging.

(c) Traction motor blowing and pressurisation of high tension compartment.

(d) Resistance fans.

(e) Regenerative brake.

(f) Air conditioning.

(g) Automatic notching and transition change.

(h) Cab heaters, hotplates, demisters.

Effect

The alarm circuit will be energised causing the blue light to shine and alarm bell to sound. The battery ammeter will also register a discharge. Should the defect be on the motor side of the alternator the red fault light (FIL) will also shine.

Remedy

Return powering or regenerating handle to "OFF" position. Press reset button to reset high speed breaker.

The following items are to be checked:-

(a) Line voltmeter indicates overhead supply.

(b) Press "Pan up" button to reset auxiliary relay (AR)

(c) Press reset button to reset high speed breaker (HSB)

(d) Supply indicator switch (SIS).

(e) Train control breaker (TCB).

(f) Motor alternator control breakers (MACB).

(g) Supply isolating breaker (SIB).

(h) Alternator circuit breaker (No. 2 end R wall).

If the alarm still operates manually operate both auxiliary relay reset buttons.

When the defect cannot be rectified to silence the alarm and extinguish the blue light turn off the supply isolate switch on the circuit breaker panel.

Under these circumstances, the motor alternator is a

failure, the traction motor blowers and resistor blower fans will not operate.

When the defect cannot be rectified or no defect is evident move the emergency light locomotive switch to the emergency position and proceed as a light locomotive.

Notching is only possible in positions 1 to 3 of the accelerating handle and the locomotive can only be operated up to full series.

The ammeter readings are to be controlled during notching in resistance up to a maximum of 400 amps which restricts operation to light locomotive running only.

The notching of starting resistances out of circuit must be completed within sixty (60) seconds to prevent overheating of the resistances without the blower fans.

Should this period be exceeded, then power to the traction motors is interrupted and cannot be re-applied for a period of three minutes. The failed resistor blower amber light will shine and alarm bell will sound.

When operating under these conditions, the following ammeter readings must not be exceeded.

150 amps continuous
230 amps for twenty five (25) minutes
270 amps for fifteen (15) minutes

Regenerative brake is inoperative.

POWER FAULT INDICATOR RED LIGHT SHINES

Whenever the line switches open on fault with the accelerating or regenerative handles in the open position and the control circuit is complete, the red light will shine and alarm bell will sound.

In addition, upon the line switches opening the motor alternator (MA) set will also stop and therefore the blue light will also shine.

The energising of the alarm circuit will cause the light(s) to shine on the affected unit and the alarm bell to sound on all units due to the following:-

1. Fault in traction circuit.
   One of the following circuit breakers may be tripped.
   Train Control, control positive or pilot motor.

2. Overcurrent to traction motors (overload relays tripped 1400 amps).

3. Fault on motor alternator (stopped).

4. Overvoltage relay tripped (2050 volts)
   applies in either motoring or regeneration.

5. Failure in camshaft control (Pilot motor circuit breaker tripped or camshaft not returned to start position.

6. High speed circuit breaker tripped.

7. Opening of control governor (Pneumatic control switch).

8. Loss of overhead supply (check line voltmeter. No volt relay may have operated).

9. Resistance overheat detector operated (amber light and bell functions).

10. Polarity detector 10 amp fuse blown when operating in Regenerative braking.

To assist in rectifying the defect, press the fault reset button with the accelerating or regenerative brake handle in the "off" position. Should this action fail to correct the fault, the following items of equipment are to be checked:-

(a) Train control, control positive or pilot motor circuit breakers are not tripped.

(b) Brake pipe pressure exceeds 350 kPa to close control governor (Pneumatic control switch).

(c) Resistance overheat device has not functioned which is indicated by the presence of the amber light and bell.

(d) Test and if necessary, renew any one of the three (3) ten amp fuses in the high tension compartment viz:- positive and negative polarity detector and no volt relay fuses.

When the indicator light shines when powering, return the powering handle to the off' position and press the reset button. The indication will be extinguished and bell ceases to sound after the motor alternator restarts.

Note: The reset button is not effective when the reverser handle is in 'isolate' or the train control circuit breaker (TCB) or control positive circuit breaker (CPS) is in the 'off' position.

If the alarm bell and indicator light operate again before operating the accelerating handle or regenerative handle of the master controller, this indicates a failure of the motor alternator (Isolate the motor alternator) or camshaft wrongly located, in which case enter high tension compartment. Check:-

Vernier camshaft on zero (c)
Resistance camshaft on 1-2.
Weak Field camshaft on SF4

if not correctly located operate small wheel to rotate armature of respective pilot motor which will cause correct alignment of contacts for operation.

When a defect is not evident, check line voltmeter is registering and if so, check the ten (10) amp no volt relay fuse in the high tension compartment and renew if necessary.

If the alarm bell and the indicator light operate again when the accelerating handle is open, the unit should be isolated.

Do not reset repeatedly because it may seriously damage the electrical equipment.

When the alarm operates in regenerative braking return the regenerative handle to the 'off' position if the alarm ceases to operate it would indicate the overvoltage relay had operated.

If the alarm operates repeatedly do not continue to use regenerative braking. Turn off regenerative brake control breaker (RCB).

In the event of the indicator light not being extinguished by returning the regenerative handle to the off' position press the reset button. If the alarm operates when regenerative brake is reapplied after resetting do not use regenerative braking.

FAILURE OF ALTERNATING CURRENT (AC) SUPPLY FROM THE MOTOR ALTERNATOR OR BATTERY CHARGER INOPERATIVE

The alarm circuit will be energised causing the blue light to shine and alarm bell to sound should the failure occur on the motor side of the alternator, then the red fault light will also shine with the accelerating and/or regenerative brake handle in the 'off' position.

The following items are to be checked:-

1. Line voltage is more than 1100 volts.
   Note: If the line voltage is less than 1100 volts then the no volt relay will function.

2. Accelerating and regenerative brake handles are in the 'off' position.

3. Press the fault reset button if the red indicator light is shining.

4. Motor alternator (AC) supply circuit breaker is not tripped.

5. Battery charger circuit breaker is not tripped.

6. Supply indicator circuit breaker is not tripped.

When the defect cannot be rectified or no defect is evident, move the emergency light locomotive switch to the emergency position and proceed as a light locomotive.

To silence the alarm and extinguish the blue light, isolate the motor alternator by turning off the supply isolate switch.

Under these conditions, the motor alternator is a failure, the traction motor blowers and starting resistor blower fans will not operate. Notching is only possible in positions 1 to 3 of the accelerating handle and the locomotive can only be operated up to full series.

The ammeter readings should be controlled during notching in resistance to a maximum of 400 amps which will restrict operation to light locomotive running only.

The notching of starting resistances out of circuit must be completed within sixty (60) seconds to prevent overheating of the resistances without the blower fans.

Should this period be exceeded, then power to the traction motors is interrupted and cannot be re-applied for a period of three (3) minutes.

In addition, the failed resistor blower fan amber light will shine and alarm bell will sound. When operating under these conditions, the following ammeter readings must not be exceeded.

150 amps continuous
230 amps for twenty five (25) minutes
270 amps for fifteen (15) minutes

Regenerative brake is not available.

FAILED FAN OR RESISTOR OVERHEAT DETECTOR

The alarm circuit will be energised causing the respective amber light to shine and alarm bell to sound.

The following items of equipment are to be checked:-

Ascertain whether traction motor blower or resistance blower fan is defective.

(a) If thermal overheat detector operates. The amber light will shine and it will be necessary to press the fault reset button.

(b) Check blower motor control circuit breaker (BMCB) is "ON".

(c) Check traction motor blower circuit breakers are "ON".

(d) Check resistance blower circuit breaker (RBB) are "ON".

Note: There is a time delay in blower fans starting up when accelerating handle is opened as previously described.

When the defect cannot be rectified, the locomotive is only to be operated light in accordance with the following:-

If the resistance fans or traction motor blowers fail for any reason or if the thermal overheat device in the main resistance boxes operate this alarm will be energised.

A check should be made of the circuit breakers and switches.

It will be necessary to wait fifteen (15) minutes for the resistances to cool and for the alarm to be de-energised should the alarm operate more than twice in quick succession and train working conditions are not such as to permit a cooling down of resistances the unit should be considered a failure and isolated. If train working conditions would permit a cooling down of resistances; e.g reaching the top of a grade with a downhill or lighter grade, continue with operation.

Failure of resistance cooling and/or traction motor blowers the following amperages must not be exceeded.

270 amps - 15 minutes
230 amps - 25 minutes
150 amps - continuous

WHEEL SLIP/SLIDE LIGHT AND BLEEPER FAIL TO OPERATE

Remedy

(a) Check wheel slip circuit breaker on circuit breaker panel is not tripped.

Sanders will not operate

Remedy

(a) Reverser handle correctly positioned for direction and operate powering handle and return to "OFF".

(b) Control positive (CPB) circuit breaker is not tripped.

(c) Check sander magnet valve isolating cocks on right wall in machine compartment.

Horns will not operate

If main reservoir pressure is available check isolating cocks for respective cab control.

No. 1 end cab

(a) Isolating cock on bulkhead in machine compartment.

(b) Isolating cock in small compartment adjacent to hotplate.

NOTE: Isolating cock on bulkhead isolates air supply for high tension door interlock, sands No. 1 end, windscreen washer, wipers, refrigerator.

No. 2 end cab

(a) In small compartment adjacent to hotplate check lower

(b) and horn isolating cocks in open position.

NOTE: Lower isolating cock isolates air supply to horns, windscreen washers, windscreen wipers, refrigerator on No. 2 end.

Cab Amenities

Respective circuit breaker turned "ON" on circuit B panel.

PROCEDURE WHEN LOCOMOTIVE WILL NOT MOVE OR LOSES POWER WHEN MOTORING OR REGENERATING

If on a steep failing grade bring the train to a stand by applying the automatic brakes.

Return the powering handle or regenerating handle to the "OFF" position.

Check - Overhead current available.

(a) Train control circuit breaker is not tripped.

(b) Main control circuit breaker is not tripped.

(c) Control circuit breaker is not tripped.

(d) Pilot motor (PMB) is not tripped.

(e) Control positive circuit breaker is not tripped.

(f) Regenerative control breaker is not tripped.

(g) Low control air pressure.

(h) Low brake pipe air (control governor (CGV) will open and this in turn will trip the high speed circuit breaker and open the line switches.

If the motor ammeter does not read

41.

Check for	Supply is proved if:-	Action if no supply
1. OVERHEAD SUPPLY	Line Voltmeter reads or Motor alternator operates or Compressors operate	Ensure pantograph in contact with wire and pantograph isolating switches closed. High tension door interlock is properly locked.
2. BATTERY SUPPPLY	Motor alternator operate or Compressors operate or Any loco lights operate	Check battery isolating switch is closed and battery fuses are not defective.
3. CONTROL CIRCUIT SUPPLY	Motor alternator operates or Line Switches close or Indicator lamps light	Check Pilot motor control (PMB) Control circuit (CCB) Control Positive (CPB) Regenerative brake control RCB1, RCB2.

Amber Resistance Notch Indicating Light

This light is illuminated when any of the locomotives in multiple are operating with resistances in circuit during acceleration.

BRAKE CYLINDER PRESSURE BLUE LIGHT

The brake cylinder pressure blue light is provided to warn the Driver should the brakes inadvertently apply on the locomotive or on any trailing locomotive fitted with this switch in a multiple unit consist. The light is normally extinguished while ever the brakes are released.

When pressure in the brake cylinder rises to 30 kPa, the switch closes and the blue light shines. Upon the pressure falling to 10 kPa, the switch opens, the blue light is extinguished.

The brake cylinder pressure blue light is train lined through the jumper coupling and will shine on all locomotives, when the brakes are applied on one or more of the locomotives in a multiple unit consist.

Brake Cylinder Pressure Blue Light Shines

The blue warning light will shine whenever the brakes are applied and pressure in the brake cylinders exceeds 30 kPa.

Should the blue warning light shine when the locomotive(s) are being operated with the brakes released, immediate action is to be taken to release the brakes in accordance with current instructions.

NOTE: This particularly applies in a multiple unit consist as severe damage can be caused to a trailing locomotive due to the brakes failing to release from a slight overcharge of the brake pipe.

The opening of the following miniature circuit breakers may cause operating difficulties with no alarms:-

1.	Train control circuit breaker	(TCB)
2.	Control circuit breaker	(CCB)
3.	Control positive circuit breaker	(CPB)
4.	Fault circuit breaker	(FIB)
5.	Pilot motor circuit breaker	(PMB)
6.	Regenerative brake circuit control	(RCB)
7.	Wheel slip/slide circuit breaker	(WSB)

Control Governor (CGV) (Pneumatic Control Switch)

The pneumatic control switch is operated by brake pipe pressure, opening if brake pipe pressure falls below 250 kPa and closing when pressure is restored to not less than 350 kPa.

When brake pipe pressure falls and the pneumatic control switch opens, it in turn trips the high speed circuit breaker and opens the line switches, causing the red fault light to shine and alarm bell to sound.

This condition will continue until the brake pipe pressure is restored and control governor closes, with the accelerating or regenerative handle in the "off,' position and the fault reset button pressed.

INTERIM PROGRESS EXAMINATION FOR 85 CLASS ELECTRIC LOCOMOTIVE DRIVERS

1. What is the purpose of the Remote Supply Circuit breaker?

2. What is the purpose of the Control Cut Out Switch?

3. What fuses are provided in the Low Tension Circuit?

4. What fuses are provided in the High Tension Circuit?

5. Describe the positions of Reverser Handle?

6. Describe the positions of the Powering Handle?

7. What is the purpose of the Motor Alternator Set?

8. What is the function of the Power Fault Indicating Light?

9. What is the function of the Alternator Failed Blue Light?

10. What is the purpose of the Supply Isolate Switch (SIS)?

11. If the Motor Alternator fails

    (a) What is lost?

    (b) What is the remedy?

12. Explain the Resistance Notch Indicator light?

13. Explain the method of operating the Powering Handle to achieve the different combinations?

14. What is the correct method of operating the Powering Handle when moving the locomotive around the depot or where slow controlled speed conditions are required?

15. What is the correct method of operating the Powering handle during normal operating conditions?

16. Explain the operation of the Resistance Overheat detection device?

17. What is the necessary action to remedy this defect?

18. Explain the operation of the Failed Fan Alarm?

19. What is the necessary action to remedy this defect?

20. What is the purpose of the:-

    (a) High Speed breaker?

    (b) Differential Current Detector?

    (c) Overload Relay?

    (d) Overvoltage Relay?

    (e) Auxiliary Relay (AR1 - AR2)?

21. What action is required if a continual wheelslip indication is displayed during multiple unit operation?

22. What is the necessary action to raise a pantograph during preparation,

    (a) With main reservoir air supply available,

    (b) By means of the footpump?

23. What purpose is the Main Isolating Switch provided and what is driver's responsibility during preparation?

24. What is the required reaction when an alternator failure, traction motor blower or Resistor Fan failure and what amperage limitations are to be observed?

25. What is the required reaction on the part of the driver when overhead voltage is low?

INDEX	PAGE NO. 46 Cl.	PAGE NO. 85 Cl.
Acceleration in Series	21	
Amalgamation	31	103
Air Conditioning		74
Air compressor Control	9	68
Auxiliary Differential Overload Relay	8	
Auxiliary Relays, (AR1 and AR2)		67
Batteries		48
Battery Fuse Panel		54
Battery switch		76
Bogies	2	
Brake Cylinder Pressure - Blue Light		57.121
Brake Equipment	4	51
Cab	2	47
Cab Refrigerator		73
Change of Combination	26	
Changing Operating Stations		101
Compressors		51
Control and Brake Valve Handles	31	
Control Circuit		53
Control Equipment	3	48
Control of Resistance Fan Motors	10	70
Control Switch	6	
Connection of Regeneration with Air Brake	26	
Control Governor (CGV) Pneumatic Control Switch		122
Circuit Breakers and Switches		78
Demisters		73
Differential Current Detector		67
Discharged Battery		110
Division of Units	32	103
Driver's Desk		54
Driving Methods		88
Driver's, Spare and Emergency Equipment	33	109
Electrical Cupboard		81
Electric Locomotives - Multiple Units	29	
Electric Locomotives - Single	28	
External Alternating Current (AC) Power Supply		50

INDEX	PAGE NO. 46 Cl.	PAGE NO. 85 Cl.
Failed Fan Alarm		58
Failed Fan or Resistor Overheat Detector		118
Failed Motor Alternator (MA) Set		56
Failure of Traction Motor Blowers or Resistance Blower Fans		71
Failure of Alternating Current (AC) Supply from the Motor Alternator		117
Faults, Failures and Their Remedy 36		110
General Description	1	47
Heaters	12	
Hotplate		73
Headlights		73
High Speed Circuit Breaker		65
Interruption of Overhead Supply	43	
Interim Progress Examination	43	123
Isolating Cocks	12	77
Jumper Coupling		63
Jumper Wiring		64
Load Meter (Ammeter)		53
Loss of Overhead Power	27	97
Loss of overhead Power on Heavy Gradients	39	
Line Switch Red Indicator Light	42	
Manual Pantograph Isolating Switches		63
Main Isolating Switch	6	62
Master Controller	5	59
Motor Alternator (MA) Set		48
Motor Generator Control Switches	8	
Motor Combinations	4	51
Multiple Units	31	101
Multiple Unit Operation		105
No Current Relay	7	
No Volt Relay (NVR)		66

INDEX	PAGE NO. 46 Cl.	PAGE NO. 85 Cl.
Operation over points and crossovers		92
Operation of the D.H. Type Equipment		75
Operating Through Water		92
Operation of Master Controller in Regeneration	24	
Operation Procedure	21	87
Overvoltage Protection	26	67
Overvoltage Relay	7	
Pantographs	29	99
Pantograph Control	9	69
Performance	4	
Positioning of Controls for Haulage of Dead Locomotives		106
Powering Switch		53
Power Fault Indicator Red Light Shines		114
Preparation and Stabling	15	81
Protection of Train	29	
Procedure when Locomotive will not Move	40	120
Reduction of Speed	23	
Regenerative Braking	23	
Regenerative Control Handle		96
Regenerative Brake Circuit		96
Remote Supply Circuit Breaker		50
Resistance Notch Indication		58
Resistance Fans Test	35	
Resistance Fans and Motor Generators Yellow Indicator Lights	34	
Resistance in Series Regeneration	27	
Reversing	23	
Running Notches	22	
Section Insulations in Overhead Wire	23	
Shunting and Low Speed Control in Series Combination		92
Stabling	33	106
Start in Series Regeneration	27	
Special Driving Conditions		93
Starting and Vernier Resistances		70
Supply Isolating Relay (SIR)		50
Supply Isolate Switch (SIS)		50
Switches and Circuit Breakers	13	

INDEX	PAGE NO. 46 Cl.	PAGE NO. 85 Cl.
Traction Motors	3	47
Traction Motor Blowers		69
Transition from Series to Series-Parallel	21	91
Transition from Series Parallel to Parallel	2	91
Vigilance Control Equipment		75
Weak Field Notches	22	
When Regenerative Braking Should be Used	24	
Wheel Slipping	23	
Wheel Slip White Indicator Light and Bleeper	11	119
Wheel Slip and Slide Correction		72
Wheel Slip and Slide Correction in Regen. Braking		73
Wheel Sliding During Regeneration	26	